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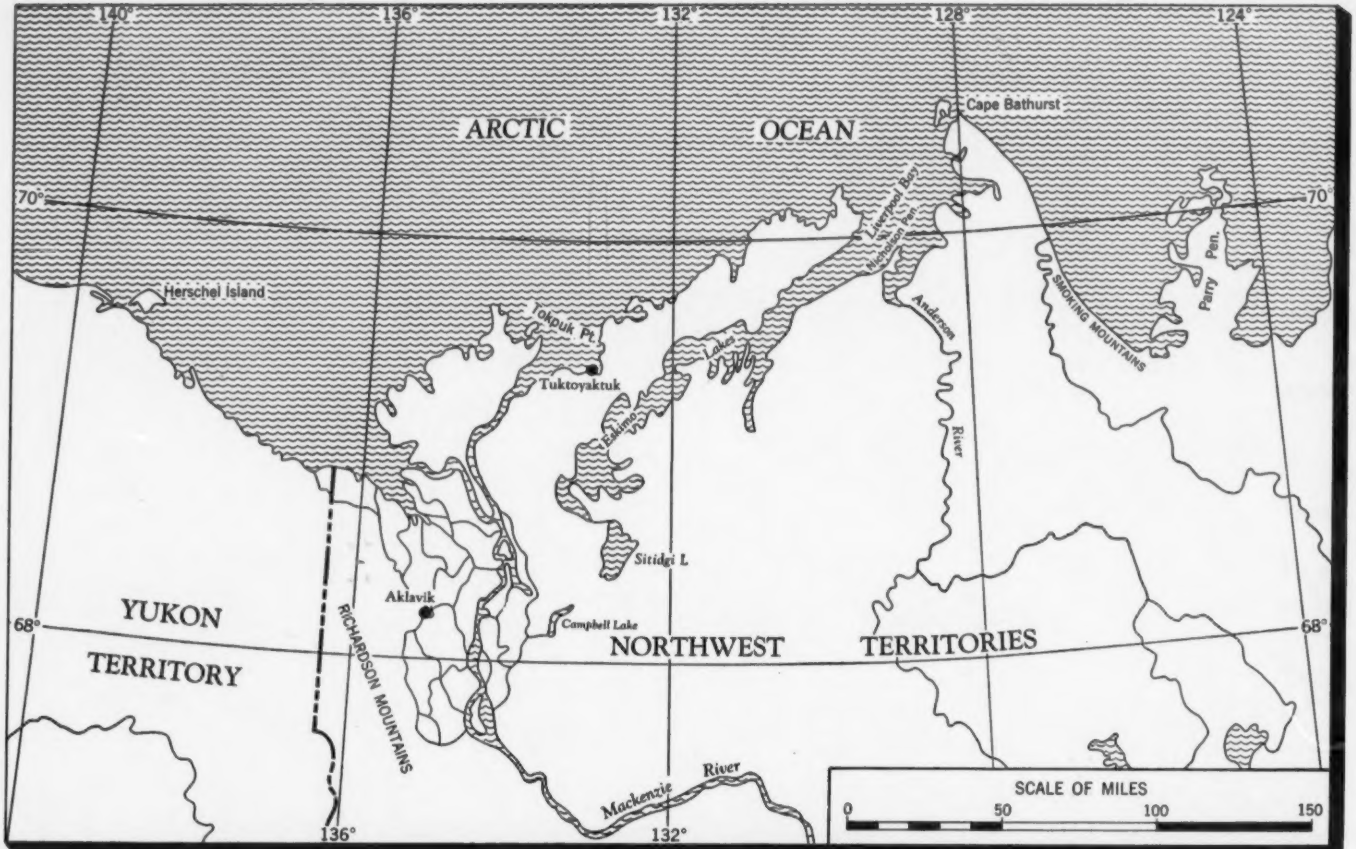

Fig. 1. Mackenzie Delta and Liverpool Bay area.

Fig. 1. Mackenzie Delta and Liverpool Bay area.

DEFORMATION BY GLACIER-ICE AT NICHOLSON PENINSULA, N.W.T., CANADA*

J. Ross Mackay†

Introduction

The capability of glacier-ice to deform consolidated and unconsolidated sediments on a regional scale has been well established, although there are relatively few good examples to show it. The action of glacier-ice has produced various types of deformation, such as broad flexures, warps, folds, and thrust faulting. Deformation by glacier-ice is superficial and has no deep-seated tectonic significance. There are at least two excellent examples of deformation by glacier action in the Western Arctic of Canada, one at Nicholson Peninsula at the southern end of Liverpool Bay, and the other at Herschel Island, Yukon Territory, 250 miles to the west (Fig. 1). It is the purpose of this paper to discuss the effects of deformation by glacier-ice at Nicholson Peninsula. Field work was done in the summer of 1954 in the Eskimo Lakes-Tuktoyaktuk area; in 1955 at Nicholson Peninsula and vicinity; and in 1956 a brief stop was made by W. H. Mathews and the writer at Herschel Island. The writer would like to thank Jack K. Stathers for his assistance in 1955 and Professors W. H. Mathews (Department of Geology) and R. A. Spence (Department of Civil Engineering) of the University of British Columbia for helpful advice and discussion on various problems.

Nicholson Peninsula (Fig. 2) is about 8 miles long and from 2 to 4 miles wide. The northern half is hilly, the southern half is flat and low. Altitudes in the northern half of the peninsula attain 200 to 300 feet above sea level in the higher western portion, whereas those in the southern half rarely exceed 30 feet above sea level. The greater altitudes of the northern half are believed to have been caused by pushing induced by moving glacier-ice. The portion affected by ice push is at least 5 miles long and in places up to 4 miles wide. Since cliff recession is rapid along the coast, especially on the exposed north-west side, the deformed zone was formerly larger. The hills of the northern half of Nicholson Peninsula rise considerably higher than adjacent mainland areas with similar formations, such as those south of Cape Bathurst and north and south of the Eskimo Lakes. The conical ice-cored hills, called pingos, that are very numerous east of the Mackenzie Delta (Mackay, 1956; Porsild,

*Based on field investigations carried out for the Geographical Branch, Department of Mines and Technical Surveys, Ottawa, with whose permission this paper is published.

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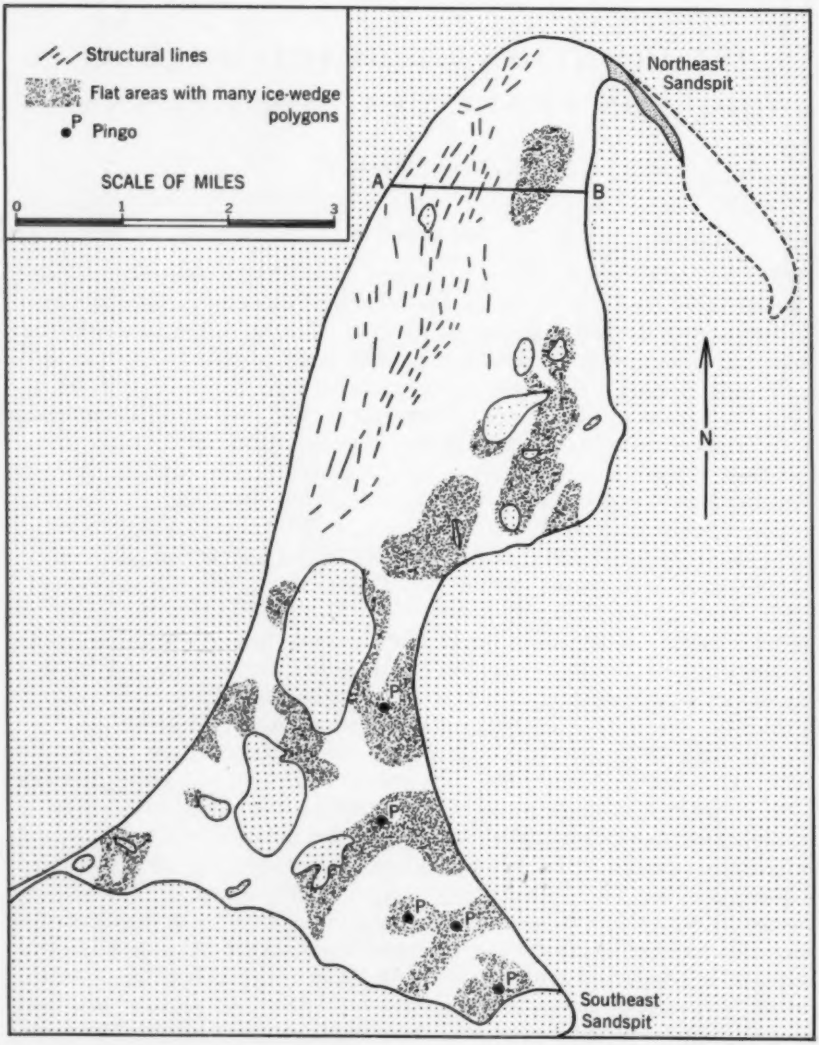

Fig. 2. Nicholson Peninsula, showing structural lines, major areas with ice-wedge polygons, and pingos. The section along A-B is shown in Fig. 4. This map has been drawn from uncontrolled air photographs and is subject to slight errors in scale.

1938; Stager, 1956) are absent in the northern half, but occur in the southern half of the peninsula. The five pingos in the southern half rise 20 to 40 feet above the polygonal ground of old lake bottoms, from which they have bulged up and grown like huge blisters. The absence of pingos in the northern half would seem to indicate conditions unfavourable for pingo formation.

Material

Nicholson Peninsula is composed of sands, silts, and clays, with ground-ice segregations in the form of tabular sheets, wedges, veinlets, etc. The sediments are probably Pleistocene in age and largely of marine origin. A small pelecypod, *Yoldia arctica*, (Wagner, 1956) occurs abundantly in the clay. Water-worn twigs, branches, and logs are also fairly common. Some of the plant remains look as fresh as modern driftwood, whereas others are carbonized and resemble charcoal; a few fragments are strongly iron-stained. Similar material occurs in the region of the Eskimo Lakes and Cape Bathurst.

The clay beds are 5 to 20 feet thick and without visible stratification. Gravel lenses occur in some clay members. The clay breaks readily into blocky fragments. The sandy beds are up to 60 feet in thickness; some are without visible stratification, others cross-bedded, and a few are finely laminated. Tabular sheets of ground ice have grown in situ in many parts of the peninsula, although the exposures are naturally best displayed along the coast. The ice sheets are 5 to 10 feet or more in thickness and are cut in places by vertical ice wedges that underlie the fissures of large polygons. Several ice sheets lie buried beneath a discontinuous bed of windblown silt up to 40 feet thick. Although the growth of ice segregations has undoubtedly contributed a share to the disturbance of the overlying and adjacent deposits, this mechanism is quite incompetent to produce the extensive deformation present in the northern half of the peninsula, because of the structure of the beds and the small amount of ice involved. In addition, it seems pertinent to stress the fact that ice segregations are more abundant in the southern half of the peninsula than in the northern half.

Structure

The general structural lines of Nicholson Peninsula (Fig. 2) are displayed with remarkable clarity on air photographs (Fig. 3). The fine details are not obscured by trees or bushes because the area lies within the tundra and most of the vegetation is only a few inches high. The air photographs show a ridged pattern suggestive of bedrock outcrops striking parallel to the west coast. However, the smooth contours, lack of angularity, and numerous gullies indicate unconsolidated material and not bedrock. The structural lines which are so clearly delineated on air photographs cannot be easily discerned on the ground, because the field of view is too limited to encompass a repeating pattern.

A none too successful attempt was made to map the material exposed in the ridges and depressions. Six exposures were examined on ridge crests; all were of sands and silts and none of clays. Solifluction, slope wash, and vegetation have obscured the sequence in the depressions (Fig. 4).

Structural features are best exposed along the bare sea cliffs. At the northern tip of the peninsula the commonest sequence is clay over sand. The cliffs are 80 to 100 feet high but the lower slopes are so covered with slumped material that the sequence there is difficult to determine. The strata have a general westerly dip of 15 to 20 degrees. The beds are locally deformed and contorted. Small folds, drag folds, and other features indicate thrust acting from the west. The amplitudes of the individual folds are small, usually of the order of 5 to 10 feet. Folding is greatest in interlaminated beds of sand and clay, where each layer is only a few inches thick.

The bluffs of the western side of the peninsula differ from those of the northern side in being lower, covered with vegetation, and consisting of sands and silts without clay members.

The bluffs of the east side of the northern half of the peninsula are from 10 to 40 feet high. They are cut into sands, silts, and clays, with silts being the most abundant. On the east coast, one mile south of the base of the long "northeast" sandspit, a cutbank exposes a section with fault planes so closely spaced—often at intervals of only one inch—that they give the appearance of bedding planes, although no bedding is visible. Some fault planes are horizontal, whereas others are curved, both upward and downward. The shear surfaces are smooth to the touch, slickensided, and streaked with crushed fragments of clam shells (*Yoldia arctica*). The slickensides trend approximately east-west. The shear planes can be followed back into the bluff by detaching blocks of clay.

Ice push

The structural features of Nicholson Peninsula could have been produced only by the pressure of glacier-ice or by earth movements. The localization of the structural features in Nicholson Peninsula rules out earth movements, as has been argued by other writers for similarly disturbed areas (e.g. Slater, 1926-27a, pp. 298-302; 1926-27b, pp. 303-15). No tectonic movements involving Pleistocene deposits are known in the area. Slumping could not explain the disturbance, because there is no higher land nearby.

In the literature of ice pushing several different mechanisms for producing deformation have been described. These mechanisms are not always distinct, for they may occur singly or in combination, depending on such varying conditions as advance or retreat of the ice, encumbent load, nature of the subjacent material, and type of topography encountered by the ice. The different mechanisms of deformation may be grouped into three categories.

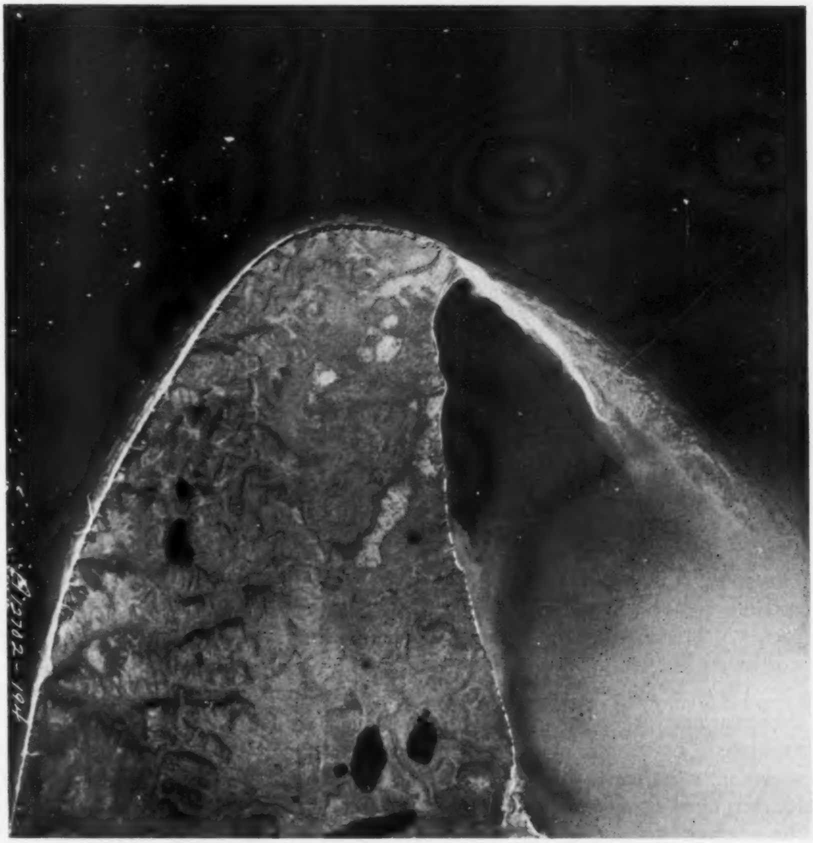

Fig. 3. Air photograph of the northern portion of Nicholson Peninsula showing the structure of the deformed beds along the west side of the peninsula. North is at the top. Note the northeast sandspit and the wave-cut cliffs. Royal Canadian Air Force photograph.

1. The pressure of glacier-ice as it advances against and possibly over a topographic obstruction causes deformation (Fuller, 1914, pp. 201-7; Hopkins, 1923).

2. The drag effect of ice moving over weak strata produces deformation (Slater, 1926).

3. The advancing ice incorporates as englacial material the subjacent beds, which are later preserved in their deformed shapes by the melting of interstitial ice (Woodward, 1903; Slater, 1926-7a, pp. 289-302; 1926-7b, pp. 303-315). The deformed beds are envisaged as retaining their relative

positions by the slow melting of interstitial ice so that the present structures represent those of a fossil glacier whose "hard parts" have been preserved (Slater, 1926, p. 396).

The structure of Nicholson Peninsula seems best explained by the first two mechanisms, whether operating singly or in combination. If the ice advanced against a topographic obstruction, such as a valley running transverse to the direction of ice movement, it may have shoved and faulted the material to form a large push moraine. This is the type of structure that has been recognized in the Long Island deposits of New York, where the glacier-ice found opposed to its advance the thick series of gravels previously deposited at its front (Fuller, 1914, pp. 206-7). The drag effect of ice moving over a continuous sheet of weak sediments may also have produced deformation. The sections exposed along the cliffs of Nicholson Peninsula resemble in many respects those beds with a uniform direction of dip that have been reported from the ice thrust beds of Mønens Klint, Denmark (Slater, 1926-7a, pp. 209-302).

If the strata had been removed from a horizontal surface, then the original position would now be marked by a depression. Unfortunately, there are too few soundings west of Nicholson Peninsula to test the theory, although it may be pointed out that the greatest known depths (8 to 11 fathoms) within at least 20 miles of the peninsula are those within 2 to 3 miles of the west coast. However, it is interesting that there is an isolated depression with depths exceeding 200 feet in the direction and position from where the deformed sediments of Herschel Island could have been shoved into position by ice moving northwest along the arctic coast.

There is little evidence to support the third or englacial mechanism of deformation. According to this theory, which has been expounded most vigorously by Slater, material that was once horizontal was incorporated as sheets into the ice and subsequently split up by numerous thrust planes near the terminus of an overloaded stagnant glacier front. A major objection to the englacial theory is that it provides no means for lifting thick sheets of sediments off the ground prior to their incorporation as englacial material in the ice. It seems difficult to conceive of any way whereby thick beds could have been incorporated into the ice except through an initial stage of folding or thrust faulting. However, if the possibility is granted that thick sheets could be incorporated as englacial material, shearing in the ice would gradually slice up the thick sheets into thinner and smaller ones. But sheets at least 60 feet in thickness occur at Nicholson Peninsula and the major structural lines can be followed almost without a break for at least 5 miles. Therefore, it seems doubtful that such a perfection in structure could have survived the disturbance that englacial material would have undergone during incorporation, transportation, shearing, and final deposition by melting of interstitial ice.

The overturned folds in the strata suggest ice push from the west. It should be emphasized that the time of deformation is unknown. It could have been during the last advance of the ice or earlier. If the disturbance had resulted from two periods of ice advance, the structure would probably be

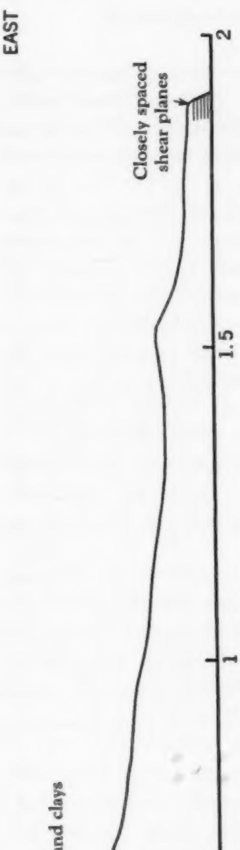

Fig. 4. Profile along the line A-B in Fig. 2. Note the higher western side of the peninsula. The dip of the strata on the ridge crest was not measured at the exact location of the profile, because no good sections were available, but was measured farther north in gullies and along the coast. The profile may be considered to be a general one for the northern part of the peninsula. Altitudes were obtained from two altimeters and distances from uncontrolled air photographs.

more complex than it is, because it is unlikely that the directions of two different movements would coincide to give the simple pattern that is present. The last movement of ice in the region of Nicholson Peninsula was affected by at least two major factors: the area was near the limit of the advance of the ice and the obstacle of the Richardson Mountains profoundly influenced the movement of the ice as far east as the Anderson River. In addition, the movement of the ice east of the Anderson River may have been affected by the ice lobe that moved across Parry Peninsula west to the Smoking Mountains. The obstacle of the Richardson Mountains caused the ice moving northward near the apex of the Mackenzie Delta to spread like a fan, with ice pushing northwest along the arctic coastal plain toward Herschel Island and northeast along the general trend of the Campbell-Sitidgi-Eskimo lakes system toward Nicholson Peninsula. It has been suggested that the area north of the Eskimo Lakes is a gigantic end moraine, formed by ice moving in a northerly direction (Downie, Evans, and Wilson, 1953), but this is debatable, because most of the area is composed of water-laid estuarine or marine sands, silts, and clays, with only a patchy distribution of morainic material. The deflection of the ice by the Richardson Mountains can also be recognized by the rapid change in direction of glacial fluting in the area west of the Anderson River and south of Nicholson Peninsula. At 68°N and 129°W, that is, at a position some 130 miles due south of Nicholson Peninsula, glacial fluting trends southeast-northwest; at 68°55′N and 130°W the trend is south-north; at 60°25′N and 129°30′W the trend is southwest-northeast. Thus in a south-

north distance of about 100 miles the orientation of glacial fluting has undergone a shift of about 90 degrees or about 1 degree per mile. Although the direction of the last ice movement across Nicholson Peninsula is unknown, a projection of the nearby trends would indicate a direction somewhere between southwest-northeast and west-east.

There is not enough information available to indicate whether the sediments were frozen or unfrozen at the time of deformation. At the present time the area is underlain by permafrost with the active layer usually less than 3 feet thick. Material on the sea floor remains unfrozen to an unknown depth. Frozen sediments have mechanical properties approaching those of ice so that they yield to shearing stresses much as ice does near the terminus of a glacier. Whether shearing in frozen ground could have produced the smooth polish present on the shear planes in the clays of Nicholson Peninsula is uncertain. However, shearing in unfrozen clay can give a high degree of polish by remoulding of the clay as seen here. Since clay may remain unfrozen at below freezing temperatures, this factor must be taken into consideration in attempts to determine whether the ground was frozen or not during deformation.

If the sediments of Nicholson Peninsula were unfrozen when deformed, as seems possible, then they probably remained unfrozen because they were submerged beneath the sea or a lake. Further study of the strata of Nicholson Peninsula may reveal whether they were frozen at the time of deformation, and in this way information may be obtained on the level of the sea at the time of the advance of the ice. In the case of the sediments of Long Island, New York, they "were unquestionably saturated with water" when the ice passed over the area (Fuller, 1914, p. 203). At Spitsbergen, where the ground is frozen to a depth of about 320 metres, calculations and observations have shown that frozen ground extends for about 100 metres along the sea floor from the coast (Werenskiold, 1953). Beyond about 100 metres, the sea floor is not frozen. Even if climatic conditions at Nicholson Peninsula during the time of the last advance of the ice were much more severe than those of Spitsbergen at the present time, calculations based upon the theory of Werenskiold indicate that unfrozen ground would have been found on the sea floor at less than a mile from the coast; these calculations are subject to a considerable margin of error.

It may be pertinent to point out that deformed sediments occur in other areas of the Western Arctic. Herschel Island is in many ways a replica of Nicholson Peninsula, for it too is an anomaly. The island rises several hundred feet above adjacent areas of similar sediments; structural features show up clearly on air photographs; and deformation of the Pleistocene strata are observable on the ground (see, for example, O'Neill, 1924, plate V, p. 77A). Leffingwell (1919, p. 169) has stated that Barter Island, Alaska, and Herschel Island are domes of deformed Pleistocene formations, but he has not discussed the mechanism of deformation. The unusual interdigitate peninsulas or "fingers" of the Eskimo Lakes may have resulted, in part at least, from defor-

mation by glacier-ice. The arcuated "fingers", their orientation transverse to the last ice movement, and the occurrence of tilted beds in at least one place all suggest the possibility of deformation. Tilted beds of sand and gravel occur along the coast between Tuktoyaktuk and Topkak Point in a form that suggests overriding by glacier-ice more than disturbance resulting from the growth of ground ice.

Conclusions

The hills of the western side of Nicholson Peninsula have been formed by the action of glacier-ice. The ice may have moved against a topographic obstruction to construct a large push moraine, or the drag effect of ice moving over weak strata may have produced the deformation. The time of deformation is unknown; it could have been during the last ice advance or at an earlier period. Although deformation may have taken place at different times, the evidence favours a single period. There is insufficient evidence to indicate whether the ground was frozen or not at the time of deformation. The theory of deformation by glacier-ice explains why the deformed strata of Nicholson Peninsula, and also of Herschel Island, rise considerably higher than adjacent areas of similar, but undisturbed material.

References

Downie, M. J., A. G. Evans, and J. T. Wilson. 1953. "Glacial features between the Mackenzie River and Hudson Bay plotted from air photographs" (abstract). *Bull. Geol. Soc. Am.*, Vol. 64, pp. 1413–14.

Fuller, M. L. 1914. 'The geology of Long Island, New York'. *U.S. Geol. Surv. Prof. Paper*, No. 82, 231 pp.

Hopkins, O. B. 1923. "Some structural features of the plains area of Alberta caused by Pleistocene glaciation". *Bull. Geol. Soc. Am.*, Vol. 34, pp. 419–30.

Leffingwell, E. de K. 1919. 'The Canning River region, northern Alaska'. *U.S. Geol. Surv. Prof. Paper*, No. 109, pp. 1–251.

Mackay, J. Ross. 1956. "Mackenzie Deltas—a progress report". *The Canadian Geographer*, No. 7, pp. 1–12.

O'Neill, J. J. 1924. 'The geology of the arctic coast of Canada, west of the Kent Peninsula'. *Rep. Can. Arct. Exped. 1913-18*, Vol. XI, Part A, Ottawa: pp. 1A–107A.

Porsild, A. E. 1938. "Earth mounds in unglaciated arctic northwestern America". *Geog. Rev.*, Vol. 28, pp. 46–58.

Slater, George. 1926. "Glacial tectonics as reflected in disturbed drift deposits". *Geol. Ass. Proc.*, Vol. 37, pp. 392–400.

——— 1926-7a. "The structure of the disturbed deposits of Møens Klint, Denmark". *Roy. Soc. Edinb. Trans.*, Vol. 55, Pt. 2, pp. 289–302.

——— 1926-7b. "The disturbed glacial deposits in the neighbourhood of Lønstrup, near Hjørring, north Denmark". *ibid.*, pp. 303–15.

Stager, John K. 1956. "Progress report on the analysis of the characteristics and distribution of pingos east of the Mackenzie Delta". *The Canadian Geographer*, No. 7, pp. 13–20.

Wagner, F. J. E. 1956. 'Report on shells from Nicholson Island, Liverpool Bay, N.W.T., submitted by J. R. Mackay, 1956'. *Report No. P1-3-56/57 of Sect. of Stratigr. Paleontol., Geol. Surv.* Ottawa: 1 p. Manuscript.

Werenskiold, W. 1953. "The extent of frozen ground under the sea bottom and glacier beds". *J. Glaciol.*, Vol. 2, pp. 197–200.

Woodward, H. B. 1903. "On some disturbances in the Chalk near Royston (Hertfordshire)". *Quart. J. Geol. Soc.*, Vol. 59, Pt. 3, pp. 362–74.

THE BURIN SPALL ARTIFACT

J. L. Giddings

THE burin has been acknowledged as an American artifact for too short a time to have hatched a nest of progeny. Yet the thin slivers[1] that were struck or pressed from burins by the distinctive *coup de burin* appear to have been often used as tools in their own right. What shall we call them? "Burin-spall knives" or "burin-spall gravers" are unwieldy names for these delicate objects, but at the moment nothing better comes to mind.

The presence of Old World burins in America became known after our excavations in the northern Bering Sea region in 1948.[2] Since that time burins have been found to be widely distributed in the earlier sites of interior and eastern arctic America. The burins of the Denbigh Flint Complex are so far those most varied in form and they perhaps come closest in their range of forms to European burins; but in each of the several New World localities where they are found burins are the product of delicate and sophisticated flint techniques. American burins are not made of "blades" in the Old World sense, although isolated ones are made of microblades. Usually they have rather resulted from removing first a part of the edge of a broad flake that has been trimmed to a quadrangular or ovate outline. The "burin blow", unlike the strike or press that dislodges a microblade from its core, does not usually allow the spall to split in a curve from the full length of the parent piece. Instead, it causes the spall to break loose in a hinge fracture while it is still straight, leaving a ragged scar at the distal end of the burin. A burin that has had several spalls removed by burin blows displays saw-like teeth approximately parallel to the last scar, as in Fig. 1.

The one feature of a burin that identifies the object beyond doubt is, of course, the presence of a "negative bulb" at the point where the burin blow has been delivered (Fig. 1 and Plate I). This is an essential effect of the technique and provides a scoop-shaped cutting edge that shaves razor-like at the bottom and edges of a groove when the burin is drawn edgewise toward the user. Most of the burins from Cape Denbigh and other American sites that I have examined closely are "angle oblique" burins (Burkitt, 1920, p. 308)[3] such as would lend themselves best to this use (as would also the forms of

[1] *Lamelles de coup de burin* (Bourlon, 1911, p. 272), or burin spalls (Noone, 1934, p. 82).

[2] Giddings, 1949 and 1951; Hopkins and Giddings, 1953. The last reference concerns the dating of the three cultural horizons at the Iyatayet site, where the burins are believed to date from a period 5,000 to 8,500 years ago.

[3] or "bevel-scaled" (Noone, 1934, p. 84).

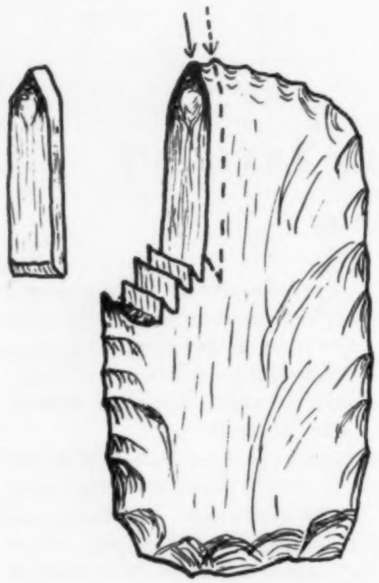

Fig. 1. Diagrammatic angle burin of one Cape Denbigh type and detached spall. Arrows designate points of burin blow.
Note negative bulb (below arrow and on spall).

beaked burin[4]). These instruments, the broad faces of which are usually nearly parallel, could serve as gauged groovers for the longitudinal sectioning of antler, ivory, and other organic material, for which process Eskimo have recently used metal blades.[5] The American burins are usually provided with a substantial stem by which they could have been end-hafted in the manner of Eskimo men's knives. Although none has thus far been found in a handle, this means little, since organic materials are absent, or nearly so, in the burin sites.

The Denbigh Flint Complex at Iyatayet has consistently yielded about twice as many burin spalls as burins. Some displaced burin spalls may have been lost in the mud and midden of the younger part of the site. The Flint Complex layer is normally only the thickness of a chalk mark on top of a

[4]see Bourlon, 1911, especially Fig. 1, p. 268.

[5]No doubt the "burin-like" instruments of ground stone that are reported from many early arctic sites were used in the same manner, as was first elucidated by de Laguna (1947, p. 193), and enlarged upon by Collins (1953, pp. 36–38). I have observed in several archaeological sites of western Alaska that sections of antler and ivory have been first split into a number of slivers with wedge-shaped cross-sections and then whittled or smoothed into arrowheads or other objects. Some of the original sections were only partly finished and show that this splitting was done primarily by grooving. In 1939, while excavating the house of Okvik Culture at Gambell, St. Lawrence Island (Rainey, 1941, p. 471), I found numbers of burin-like instruments of polished stone in association with walrus tusks in various stages of sectioning and was impressed with the likelihood that in one or two cases I had fitted the grooving instrument into the groove that it had been in process of making when the house was abandoned.

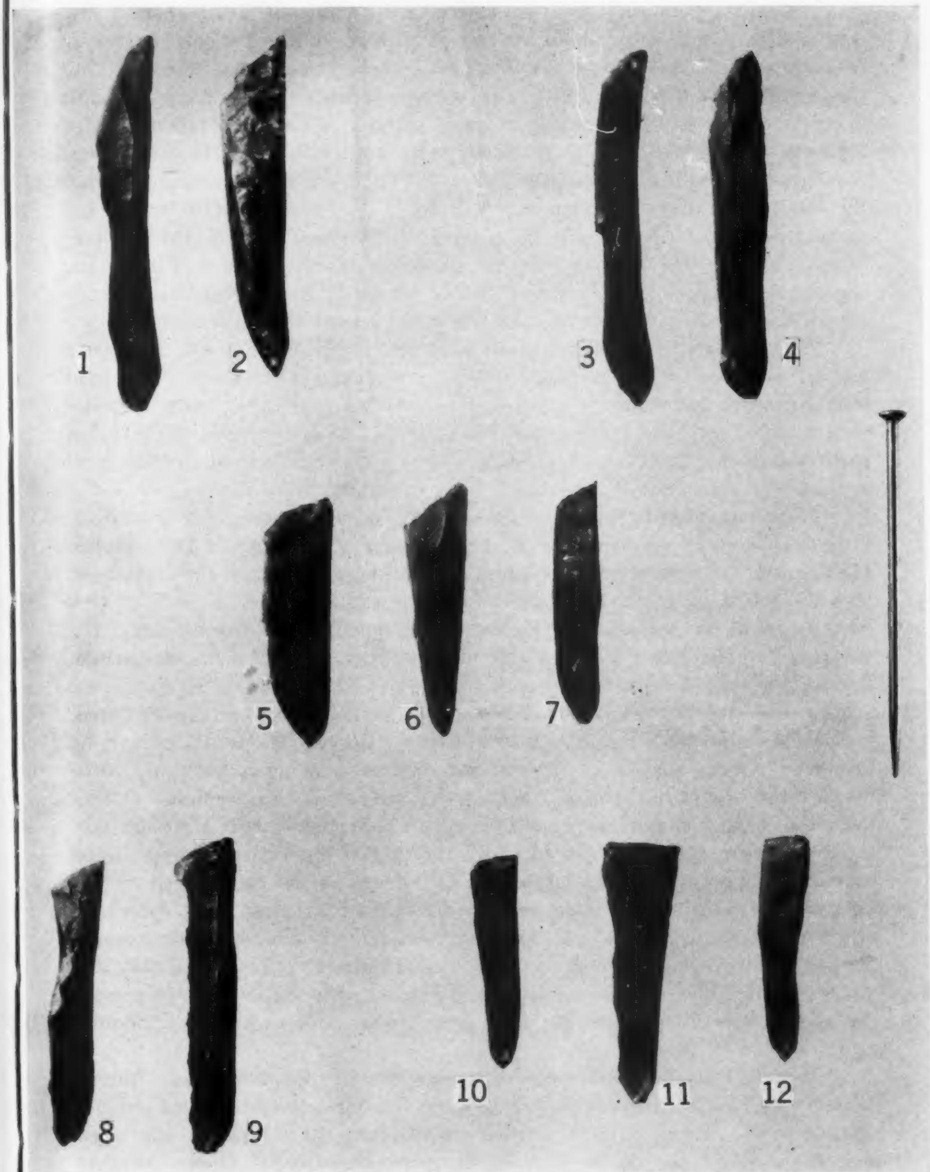

Plate I. Burin spalls of Cape Denbigh type, magnified. Note one-inch pin at right to give scale.

dense clay and since we have been able to proceed with great caution in that range, we have presumably lost no appreciable number of burin spalls in situ. The spalls are most often about the size of a spruce needle and, like it, usually of rectangular cross-section. A few reach three centimetres in length, but the majority are much shorter. The first spall struck from a prepared burin "core" is likely to be triangular in cross section, the original trimmed edge forming one or two of its three faces. This kind of burin spall shows only the "positive" bulb of percussion (Plate I, 2). All the spalls removed from the burin core after the initial one will be, if they are correctly struck (or pressed?), four-sided and will show both the negative bulb of the previous burin blow and the positive bulb of the latest blow. Thus in Plate I the negative bulb appears at the lower end of all specimens, except *2* and *6*. If any of these spalls were turned over, the positive bulb would be visible.

We speculated from the first on the possibility that these delicate objects had served some special purpose in their own right. They might have been inset barbs for fish hooks, preceding the ivory pegs or metal barbs of more recent arctic fish hooks. Most of our thoughts on the nature of the burin spall had to do, however, with the end at which the burin blow had been applied.

Then, one day in January of 1954, I received a telephone call from Prof. Carleton Coon, in another wing of the University Museum at Philadelphia. He wanted to know whether or not the burins in my collection had been actually dulled by use, as by grooving hard organic materials. I recalled that only a few burins appeared obviously worn, though under magnification the working end sometimes bore signs of scouring or the removal of microscopic flakes along the edges of the negative bulb. Coon then asked if I could spare a burin for experimenting to find if it would actually groove bony material. I chose a representative burin and took it to Coon's laboratory, where he produced a fresh beef bone. We found that by drawing it back and forth the flint tool did in fact groove the bone very effectively and rapidly. Moreover, the burin was not lost, as it showed no appreciable wear after the test.

Back at my desk, it occurred to me that burins must have become dulled by use if they needed sharpening as often as the scars on the Denbigh specimens indicated. Consequently, burin spalls ought to be in most cases dulled or otherwise ineffective at the working end. A quick examination under magnification failed to show that this was the case, however. Why were they not dulled? The only obvious explanation would be that they were not merely the by-products of burin use, but were meant to function as tools in their own right.

I began to examine the burin spalls in earnest under magnification. Almost immediately I found that not the bulbous, but the opposite end showed obvious signs of wear. A fine retouch, usually not visible to the naked eye, was to be seen at the distal end of the spall in the great majority of cases. Another regularity appeared. When the burin spall was placed on a flat surface with the retouched end upward, the negative bulb also lay upward at the opposite

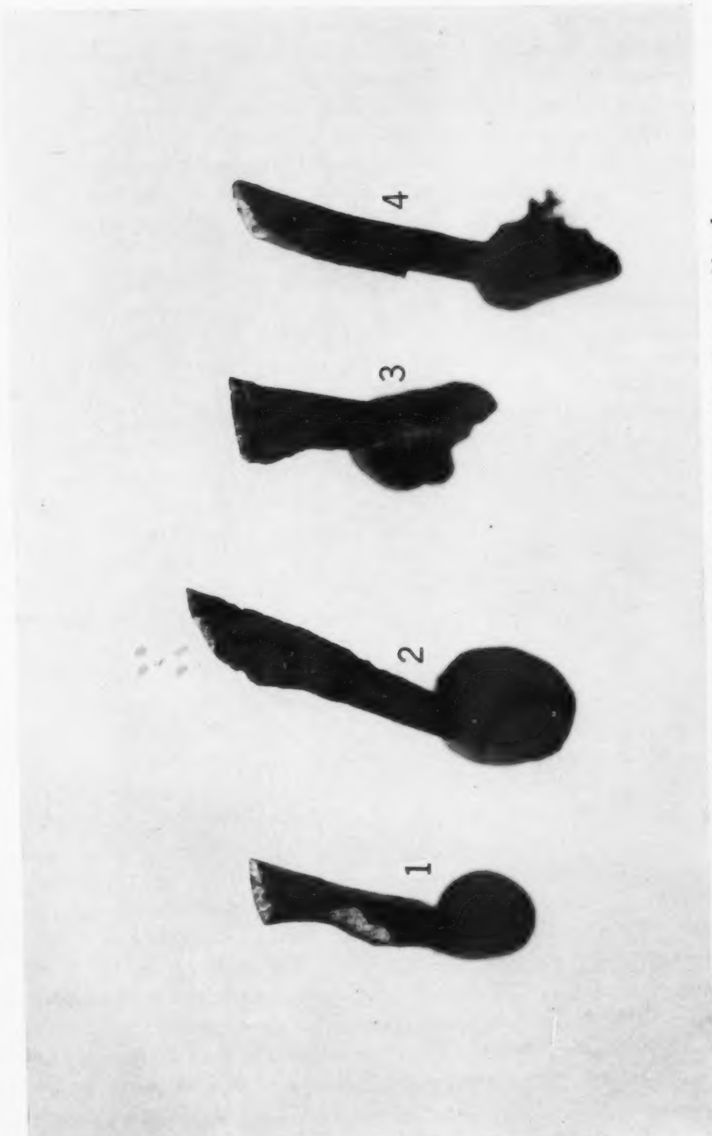

Plate II. Four burin spalls of Plate I more highly magnified to show working face.

end. This is shown in Plate I[6], in which 12 burin spalls lie with the retouched end toward the top of the illustration. The negative bulb is visible in most specimens, but no positive bulb can be seen.

The retouched area is much too small in most spalls (the pin shown in Plate I is an ordinary one-inch pin) to allow it to have been prepared by the usual process of pressure retouch. There is no doubt that the retouched areas result from use or from some shearing process, as occurs in pressing the working edge against bone or antler. Shown in Plate II are four of the spalls of Plate I, tilted in order to bring out details of the tips. It will be seen that they resemble thumbnail scrapers. Plate III shows the greatly enlarged working edge of one of the burin spalls (Plate I, *8*; Plate II, *1*).

Close examination of more than 200 burin spalls from the Denbigh Flint Complex showed that nearly all of the four-sided specimens that had been struck successfully are worked in the manner of those shown in Plate I. In most of the specimens the worked edge slants to the left (Plate I, *1-9*). A smaller number have the working edge nearly at right angles to the length of the spall (Plate I, *10-12*), and only four specimens have the worked edge sloping to the right. If the slope indicates right and left handedness, as I presume it does, the retouched burin spalls would seem to have been the tips of engraving tools not unlike those used by modern engravers. As such they would have been mounted at the end of a handle and drawn toward the worker, the sloping edge in front.

Something more can be said of these used burin spalls as regards their probable function as engraving tools. In the same way as the burin seems to have a "neolithic" successor in the burin-like instrument of polished stone, so may this burin spall artifact have its successor in the rodent-tooth and metal engraving tools at later times in the Bering Strait area. The Ipiutak site at Point Hope yielded a "penholder" form of engraving tool in many variations, often elaborately decorated, that had either the sharpened incisor of a ground squirrel or an iron point inserted in a rectangular groove at one end (Larsen and Rainey, 1948, pp. 82-84, Fig. 18, Pl. 8, *15-24*). Engraving-tool holders of the same general form are known from the palae-Eskimo levels at Iyatayet, from later cultural phases on the Kobuk River (Giddings, 1952, pp. 72-73, Pl. 43, *24*, Pl. 44, *21*) and elsewhere in the earlier Alaskan sites.[7] Engraving tools of slightly different form, holding metal bits, are known from Punuk levels on St. Lawrence Island (Collins, 1937, pp. 303-5, Pl. 60, *10-11*, Pl. 81, *17-20*).

If we are not too far afield in considering the burin spall tools to have been hafted engravers, another reasonable guess is that the Denbigh Flint people gave free rein to their artistic talents, quite possibly in the field of the elaborate art styles that prevailed in the western Eskimo area some 2,000 years ago. Thus

[6]The photographs were made in the University Museum at Philadelphia by Mr. Reuben Goldberg.

[7]Possibly the oldest object of this kind that has been illustrated is from the Okvik Culture of the Punuk Islands (Rainey, 1941, Fig. 35, *10*). It was identified by Dr. Rainey later, after he had found similar objects at Ipiutak.

Plate III. Working face of burin spall shown in Plate I, *8* and Plate II, *1*, highly magnified.

far, however, we have no organic materials from the oldest layer at Cape Denbigh, and therefore no proof of engraving skill.

Even though the burin of the Denbigh Flint Complex was probably used primarily for grooving, it must have been regarded by its makers in many cases as a core for the production of excellent burin spalls. Was this a unique local conception? I could not recall a suggestion from elsewhere that the burin spall was a tool. On turning to the few burin spalls from a site that I had recently investigated on the North Knife River of the Churchill region of Manitoba, however, I found again the retouched implement like that from Cape Denbigh.

I wrote then to Dr. Helge Larsen in Denmark, explaining the case to him, enclosing photographs, and asking him about the burin material that he had recently excavated in an early site in Greenland. He replied with enthusiasm that he and his colleagues at the National Museum had examined the burin spalls collected the previous summer at the Sarqaq site in Disko Bay, and had found that "every one of the spalls made of flint, jasper and similar minerals had the same retouch [as in the photographs] . . . , and just as fine."

As to the burin spalls as artifacts of importance in Europe during Paleolithic and Mesolithic times, I have as yet no positive information. It appears that they have most often been regarded as reject material, so that we may have to wait for some time to learn whether or not the burin spall tool is primarily a phenomenon of the American Arctic. Bourlon (1911) made use of burin spalls in his study of the burin technique, and Noone (1953) writes that the "humble burin spall . . . , a by-product in the production and upkeep of burins, is not entirely without value . . . ." as a means of learning more of the object from which it has been separated. It is hoped that someone will re-examine the burin spalls that are preserved in the museums of Europe. In the meantime it looks as though the American Arctic has produced a new form of artifact, and one quite as minuscule and specialized as can be desired in a flint technique.

References

Bourlon, Lt. 1911. "Essai de classification des burins". *Revue Anthropologique*, Vol. 21, pp. 267–78.

Burkitt, Miles C. 1920. "Classification of burins or gravers". *Proc. Prehist. Soc. of East Anglia for 1919-20*, Vol. 3, Pt. 2, pp. 306–10.

Collins, Henry B. 1937. "Archeology of St. Lawrence Island, Alaska." *Smithson. Misc. Coll.*, Vol. 96, No. 1.

——— 1953. "Recent developments in the Dorset culture area". *Asia and North America—Transpacific Contacts, Memoir No. 9, Supplement to American Antiquity*, Vol. 18, No. 3, Pt. 2, pp. 32–39.

Giddings, J. L. 1949. "Early flint horizons on the North Bering Sea Coast". *J. Wash. Acad. Sci.*, Vol. 39, pp. 85–90.

——— 1951. "The Denbigh Flint Complex". *Am. Antiquity*, Vol. 16, pp. 193–203.

——— 1952. 'The arctic woodland culture of the Kobuk River'. Philadelphia: The University Museum.

Hopkins, David M., and J. L. Giddings, Jr. 1953. "Geological background of the Iyatayet archeological site, Cape Denbigh, Alaska". *Smithson. Misc. Coll.*, Vol. 121, No. 11.

de Laguna, Frederica. 1947. "The prehistory of northern North America as seen from the Yukon." *Mem. Soc. Am. Archeology, Supplement to Am. Antiquity*, Vol. 12, No. 3, Pt. 2.

Larsen, Helge, and Froelich Rainey. 1948. "Ipiutak and the arctic whale hunting culture". *Anth. Papers of the Am. Mus. of Nat. Hist.*, Vol. 42.

Noone, H. V. V. 1934. "A classification of flint burins or gravers". *J. Royal Anth. Inst.*, Vol. 64, pp. 81–92.

——— 1954. "Burins of the Vézère Valley (Dordogne)". *Proc. Prehistoric Soc. for 1953, N.S.*, Vol. 19, pp. 116–120.

Rainey, Froelich G. 1941. "Eskimo prehistory: the Ovik site on the Punuk Islands". *Anth. Papers of the Am. Mus. of Nat. Hist.*, Vol. 37, Pt. 4.

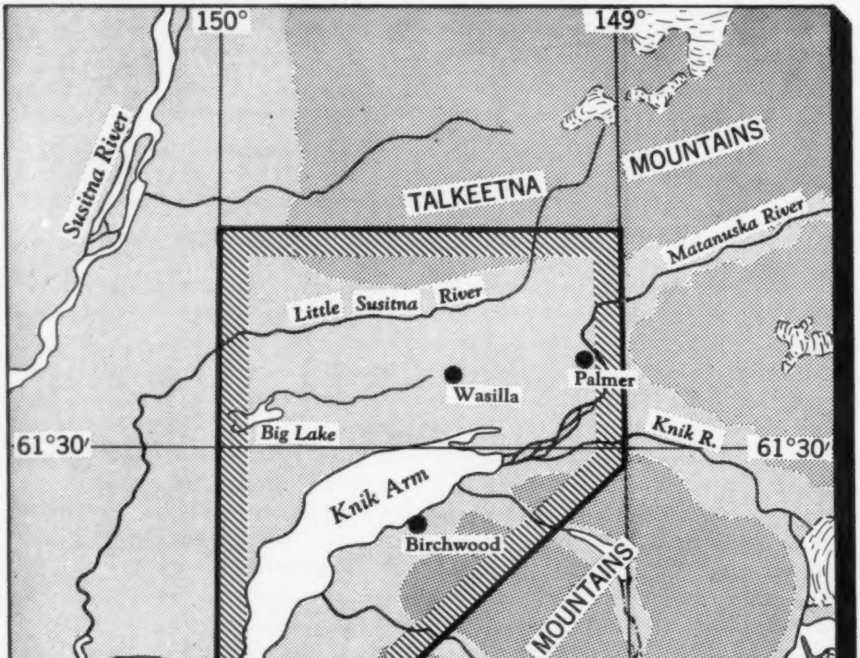

Fig. 1. Location map.

RATES OF TREE GROWTH AND FOREST SUCCESSION IN THE ANCHORAGE-MATANUSKA VALLEY AREA, ALASKA*

John C. Reed, Jr.[1] **and John C. Harms**[2]

Geographic setting

During the 1955 field season the vegetation in the Anchorage-Matanuska Valley area, Alaska, was studied as a part of an investigation carried out by the 535th Engineer Detachment (Terrain), U.S. Army Map Service. The area studied includes the lowlands bordering Knik Arm and the lower portions of the valleys of the Knik and Matanuska rivers. It extends from 61°07′ to 61°45′ north latitude. (Fig. 1). According to Sigafoos (1956) it lies in the Susitna-Copper River Spruce-Birch Forest Province. The vegetation types studied include those from sea level to tree line, which lies at an elevation of about 1,500 feet on the flanks of the Chugach Mountains and up to 2,000 feet on the flanks of the Talkeetnas. Dense alder stands extend several hundred feet above timberline.

Scope of investigation

The goal of the investigation was a forest cover type map primarily for military purposes. Choice of map units was governed by two primary considerations: logical continuity in forest succession, and ease of recognition on available aerial photographs (Stone, 1950). Eight principal forest cover types were distinguished. These are listed in the following table.

Table 1. Principal forest cover types in the Anchorage area.

I. Mature types undisturbed by recent fires
   1. Pure black spruce forest
   2. Pure white spruce forest
   3. Birch-white spruce forest
   4. Cottonwood-white spruce forest
   5. Alder thickets

II. Types representing stages in regrowth following fires or recent aggradation by streams
   1. Young birch-aspen-cottonwood stands (generally less than 40 years old)
   2. Submature birch-white spruce forest
   3. Submature cottonwood-white spruce forest

*Published by permission of Commanding Officer, U.S. Army Map Service.

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Non-forested areas are principally marsh, muskeg, or farmlands, although some slopes capable of supporting trees are only grass covered, probably because of the severity of past fires.

In the course of the field work 65 test plots with areas of one-fifth or one-tenth of an acre were laid out. Because of limitations of time the test plots were not distributed randomly, but were located in easily accessible areas typical of each forest cover type. All trees over three feet high in each plot were counted and their diameters recorded in two-inch size classes. The ages of selected trees were determined and their exact diameters and heights measured. Because of the large area covered by the birch-white spruce succession, most of the test plots were in the young birch-aspen-cottonwood forest type, the submature birch-white spruce forest type, and in the mature birch-white spruce forest type.

Distribution and rate of growth of tree types

Field mapping indicates that in general the most important factors controlling the distribution of tree species in the area studied are altitude, drainage, extent and severity of fires, regenerative ability of the species following a fire, and frequency of flooding. Except at higher elevations, exposure plays a minor role. The effects of geologic setting and soil types are negligible, except in so far as they affect the drainage. Once the trees are established, the rate of their growth depends mainly on the species, the amount of sunlight reaching an individual, the drainage, and to a minor extent, on altitude and exposure.

Figures 2 to 5 are scatter diagrams that summarize the growth rate data for birch (*Betula* spp.), white spruce (*Picea glauca*), black spruce (*Picea mariana*), and poplar (*Populus* spp.). The ages of the trees are plotted against the diameters. Site drainage characteristics are shown by symbols. Poorly drained sites include swamps and muskegs; moderately well drained sites include level or gently sloping areas underlain by impermeable glacial till or bedrock; well drained sites include areas underlain by outwash gravels, wind-blown silt, and recent alluvial deposits. Sites on shallow soil overlying till or bedrock on steep mountain sides are also classified as well drained.

Because of the effect of shading, individual trees in a stand may show growth rates much lower than those of the dominant trees. Only data from the oldest trees at a particular site are included when it was apparent that shading had retarded the younger trees significantly.

Poplar has the highest growth rate of any of the trees measured, that is, a maximum increase in diameter of 0.4 inch per year on well drained sites. Birch and white spruce have growth rates of 0.10 to 0.15 inch per year on well drained sites, but white spruce is apparently more affected by poor drainage. Black spruce has the lowest rate of growth of any of the trees measured. The average rate of increase in diameter is 0.02 to 0.05 inch per year for trees growing in muskegs and slightly higher on better drained sites.

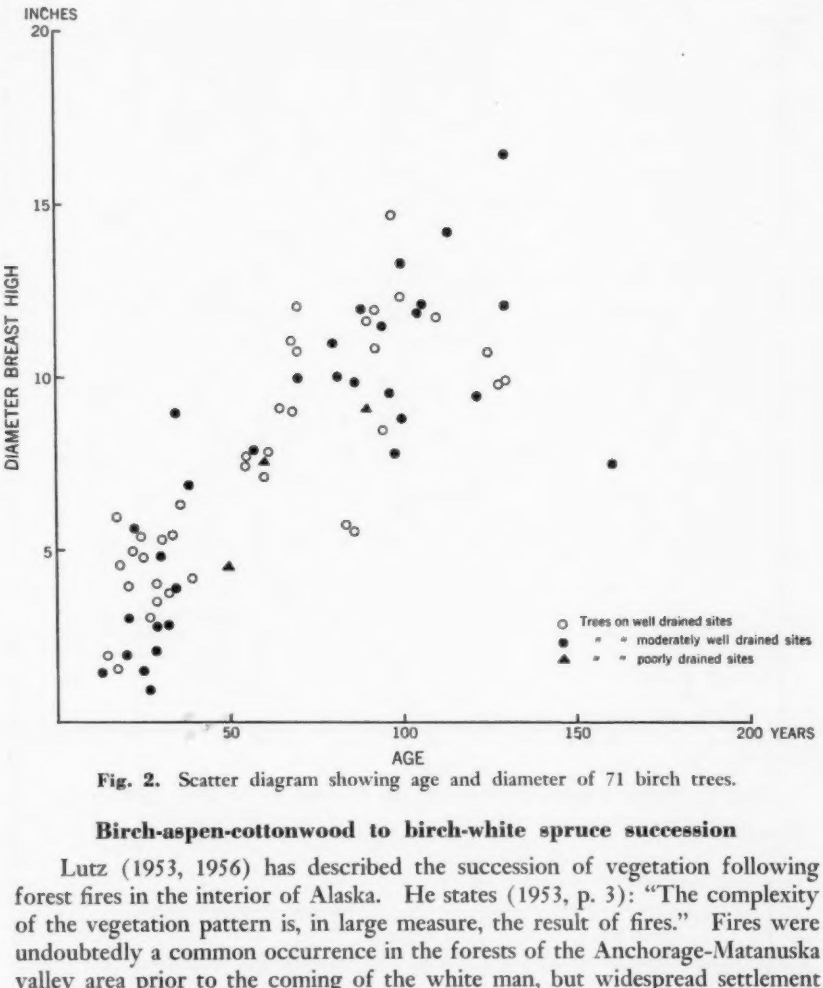

Fig. 2. Scatter diagram showing age and diameter of 71 birch trees.

Birch-aspen-cottonwood to birch-white spruce succession

Lutz (1953, 1956) has described the succession of vegetation following forest fires in the interior of Alaska. He states (1953, p. 3): "The complexity of the vegetation pattern is, in large measure, the result of fires." Fires were undoubtedly a common occurrence in the forests of the Anchorage-Matanuska valley area prior to the coming of the white man, but widespread settlement greatly increased their incidence. Extensive fires that occurred during the construction of the Alaska Railroad in 1916-17 have had a profound effect on the present distribution of vegetation types.

The forest succession that follows a severe fire on moderately well to well drained sites depends on the type of reseeding in the area. Generally the pioneer species are those with easily dispersed seeds, such as birch, aspen (*Populus tremuloides*), poplar, and willow (*Salix* spp.). The population graphs (Fig. 6) illustrate a typical succession following a severe fire in mature birch-white spruce forest. Four stages in the succession have been distinguished; these correspond to map units II-1, II-2, I-3, and I-2 of Table 1.

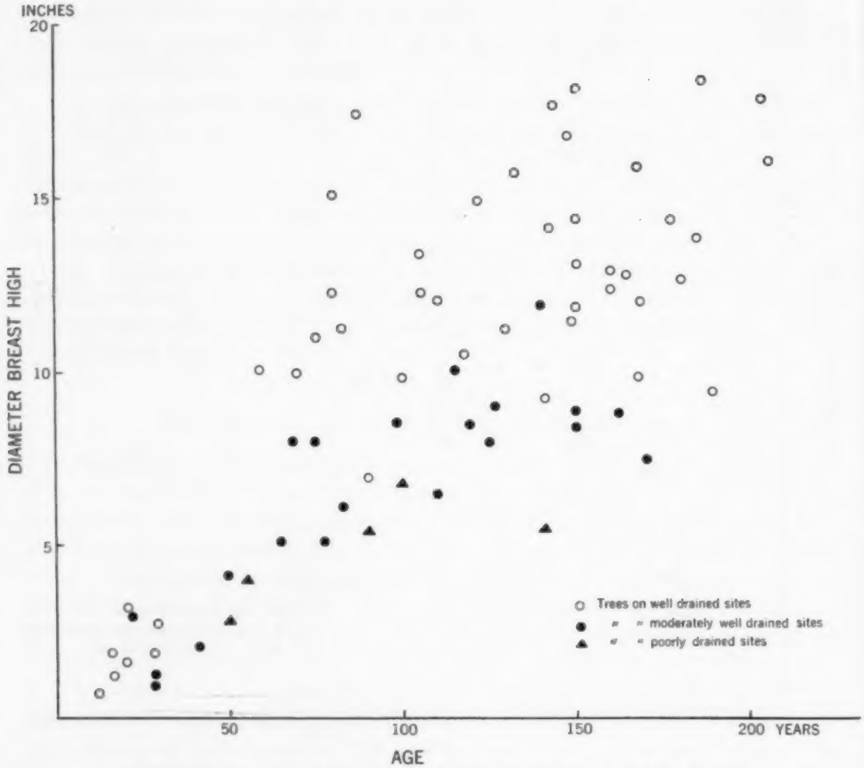

Fig. 3. Scatter diagram showing age and diameter of 71 white spruce trees.

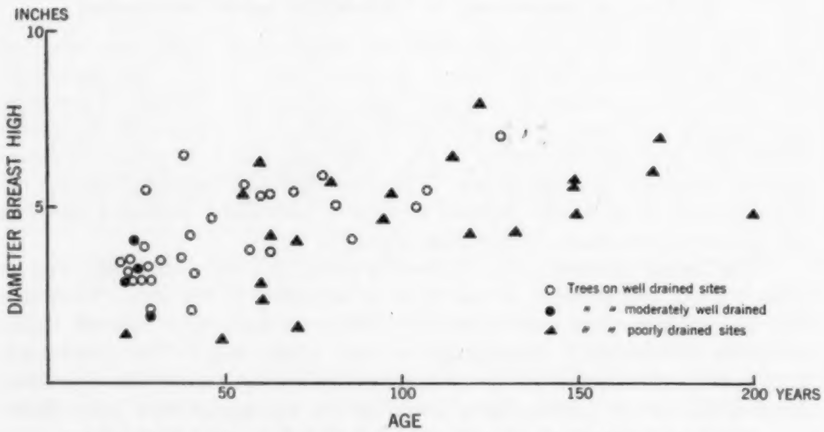

Fig. 4. Scatter diagram showing age and diameter of 55 black spruce trees.

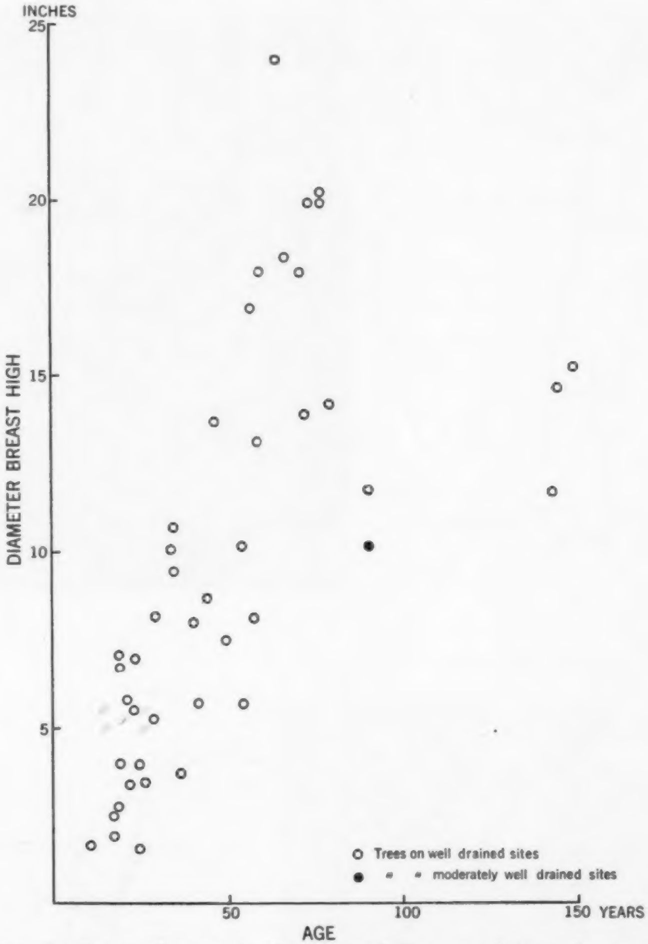

Fig. 5. Scatter diagram showing age and diameter of 44 poplar trees.

Reproduction that takes place after severe fires in mature birch-white spruce forest in the study area generally leads to a dense stand of birch saplings with an admixture of cottonwood and aspen (Fig. 7). Scattered white spruce seedlings are found in the understory. Because of the dense shade, ground vegetation is sparse and consists mainly of mosses, lichens, horsetail (*Equisetum* spp.), bunchberry (*Cornus canadensis*), low bush cranberry (*Vaccinium vitis-idaea*), and twinflower (*Linnaea borealis*). Thirty to forty years after the fire the majority of the birch are 2 to 4 inches in diameter. Stem density is very high, up to 6,000 stems per acre (Fig. 6A). The canopy density is 95 to 100 per cent and the canopy height is 30 to 40 feet.

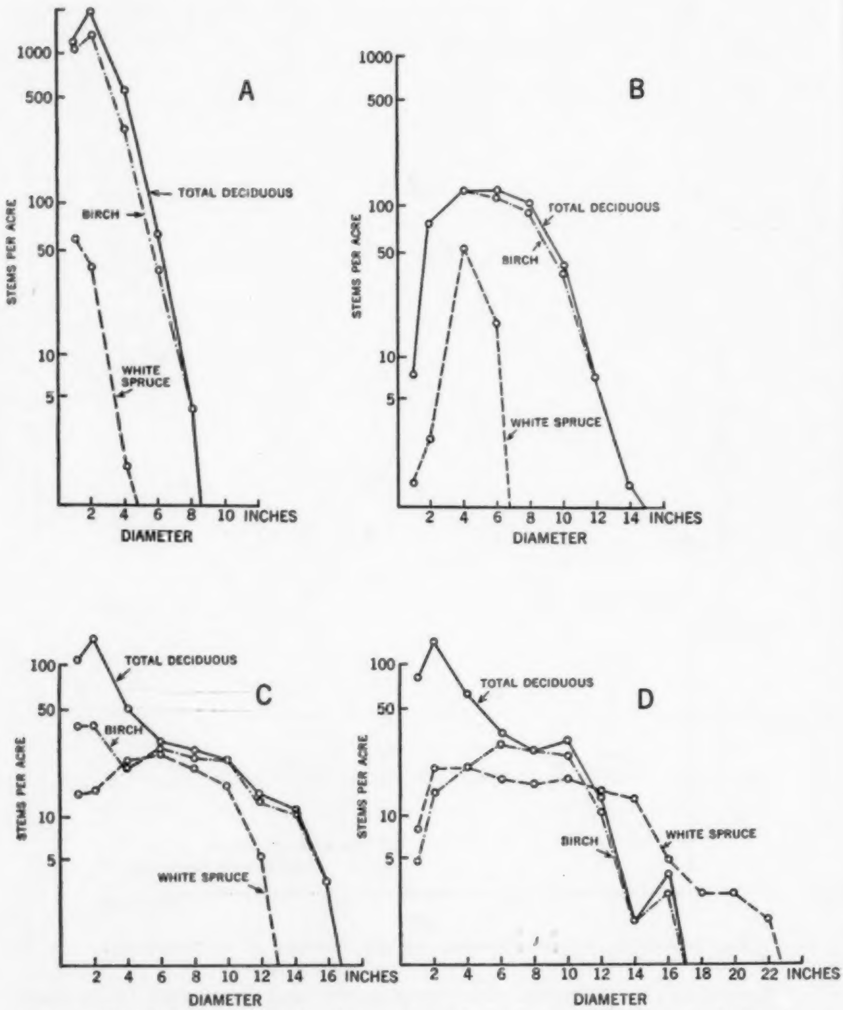

Fig. 6. Population diagrams showing number of stems per acre by two-inch size classes in four stages in the birch-white spruce succession.

A. Young birch thickets (average of 11 one-tenth of an acre test plots). Average age of oldest trees 33 years.
B. Submature birch-white spruce forest (average of 6 one-fifth of an acre test plots). Average age of oldest trees 77 years.
C. Mature birch-white spruce forest (average of 19 one-fifth of an acre test plots). Average age of oldest trees 135 years.
D. Near climax white spruce-birch forest (average of 5 one-fifth of an acre test plots). Average age of oldest trees 170 years. The age of the oldest trees probably does not indicate the age of the stand.

Fig. 7. Typical young birch thicket. Forty-year old stand of birch growing on moraine south of Big Lake (Anchorage C-8 quadrangle). Most trees are 1 to 2 inches in diameter, largest are 6 inches.

Fig. 8. Submature birch stand with understory white spruce growing on level gravel terrace near Birchwood (Anchorage B-7 quadrangle). Stand is about 70 years old. Most of the birch are 4 to 6 inches in diameter.

Fig. 9. Mature birch-white spruce stand on gravel terrace near Palmer (Anchorage C-6 quadrangle). Oldest tree is approximately 110 years, largest is about 14 inches in diameter.

Fig. 10. White spruce-birch forest on north flank of Chugach Mountains near Birchwood. Oldest tree is 177 years, largest is about 20 inches in diameter.

By the time the stand reaches 70 to 80 years, most of the dominant birch are 6 to 8 inches in diameter (Fig. 6B, Fig. 8). The spruce are 2 to 6 inches in diameter, but have not yet reached the canopy. The crown density is still high and canopy height is 60 to 70 feet. The stem density has decreased to 400 to 600 stems per acre, mainly on account of mortality among the birch. Birch is not shade tolerant so that the smaller trees do not survive; white spruce has a low mortality since it tolerates shade.

At an age of 120 to 140 years the stem density has decreased to about 200 trees of over 2 inches in diameter per acre (Fig. 6C, Fig. 9). Some of the larger birch and spruce reach 20 inches in diameter. Many of the birch are overmature and are suffering from decay and frost cracking. The density of the canopy has decreased to between 60 and 85 per cent. The canopy is made up mainly of birch. The larger spruce trees, 70 to 90 feet high, reach 10 to 20 feet above the birch canopy. Birch are able to reproduce locally in the openings left by fallen trees, this is reflected by the second maximum in the two-inch diameter class of the birch population curve. Alder (*Alnus* spp.) frequently occurs in the understory, causing the marked increase in the total number of deciduous stems in the smaller size classes. Because of the open canopy ground vegetation is quite dense, consisting mainly of grasses, high bush cranberry (*Viburnum edule*), currant (*Ribes* spp.), rose (*Rosa* sp.), devils club (*Oplopanax horridus*), and tall fireweed (*Epilobium angustifolium*).

Since spruce are longer lived and the seedlings are shade tolerant, it might be expected that normal forest succession would eventually lead to pure stands of white spruce. However, this condition is seldom reached in the study area, probably because new generations of birch arise to maintain a considerable population as soon as the canopy is opened by the death of overmature trees. The white spruce may also be killed by insects and disease and the same agents may interfere with their production of seed.

The stands showing the highest ratio of spruce to birch are found close to timberline on the north flank of the Chugach Mountains (Fig. 10). The average population of these stands is shown in Fig. 6D. The ground vegetation is similar to that of the mature birch-white spruce forest. The average age of the larger spruce is 170 years.

Other successions

Two other forest successions were noted: poplar to poplar-white spruce to white spruce; and birch-black spruce to black spruce. The former is common on well drained alluvial terraces bordering streams; the latter is found on both poorly drained and well drained soils. Not enough data were collected to prepare population curves for these successions.

Conclusions

1. Soil type and surficial geology are relatively unimportant as direct controls of distribution of vegetation in the area. Occurrence of fires and availability of seed immediately following a fire are of far greater importance.
2. Growth rate is controlled by amount of sunlight and drainage characteristics of the site.
3. Cottonwood and aspen have the highest growth rates observed. Birch and white spruce have a lower growth rate. Drainage conditions apparently have more effect on white spruce than on birch. Black spruce has the lowest growth rate.
4. In the area studied a mixed birch-white spruce forest is generally self perpetuating. Only in small areas have pure white spruce stands developed from the birch-white spruce association.

References

Lutz, H. J. 1953. 'The effects of forest fires on the vegetation of interior Alaska'. *U.S. Forest Service, Alaska Forest Research Center Station Paper No. 1*, 36 pp.

——— 1956. 'Ecological effects of forest fires in the interior of Alaska'. *U.S. Dept. of Agric. Tech. Bull. 1133.* 121 pp.

Sigafoos, R. S. 1956. 'Vegetation map of northwestern North America'. Unpublished MS in files of Military Geological Branch, U.S. Geological Survey.

Stone, K. H. 1950. "Aerial photographic interpretation of natural vegetation in the Anchorage area, Alaska". *Surveying and Mapping*, Vol. 10, pp. 199–207.

SOME FACTORS AFFECTING THE EXTENT OF ICE IN THE BARENTS SEA AREA

Francis E. Elliott*

Introduction

It is known that the areal distribution of ice in the arctic seas varies greatly from year to year, and considerable work has been done in an effort to find an explanation for this phenomenon in order to develop reliable methods of forecasting. Russian investigators are alleged to have made particularly good progress in this respect. As explained by Zubov (1948) the Russian method is based on the premise that "ice drifts along isobaric lines with a speed proportional to the pressure gradient". This method is used for forecasting from the winter and spring to the following navigation season. The weakness of this method lies in the fact that it assumes an unchanging amount of floating ice, drifting with the winds, concentrating in one part of the arctic seas and thinning out in other parts. It does not take into account the fact that ice melts when it comes into contact with warmer waters. Earlier, Zubov (1933) found a good correlation between the variation in temperature of the North Cape branch along the Kola meridian and the variation in the ice cover of the Barents Sea. This approach, however, neglected the variation in the inflow of warm Atlantic water into the area. An increased amount of warm Atlantic water obviously means an increased heat transport even if the temperature remains constant. Helland-Hansen (1934) found variations of about 20 per cent in transport across the Wyville-Thomson Ridge, and Jacobson's figures (1943) show an even greater range.

Theoretical discussion of the method

The present discussion is an attempt to explain the fluctuations in the areal extent of ice in the Barents Sea area (Fig. 1) through variations in the transport of the Florida current, as indicated by mean sea level changes at Charleston, South Carolina, and Miami Beach, Florida. This method seems entirely valid in the light of the investigations of Montgomery (1938), LaFond (1939), and Iselin (1940). They show that off a coast where the density of the water may vary owing to external influences, the variations in mean sea level have a direct bearing on the slope of the sea surface toward or away from the coast. Variations in mean sea level may thus be interpreted in terms of the slope of the sea surface, i.e., in terms of a coastal current. For the case at hand Iselin (1940) has demonstrated that increasing mean sea level at Miami Beach and

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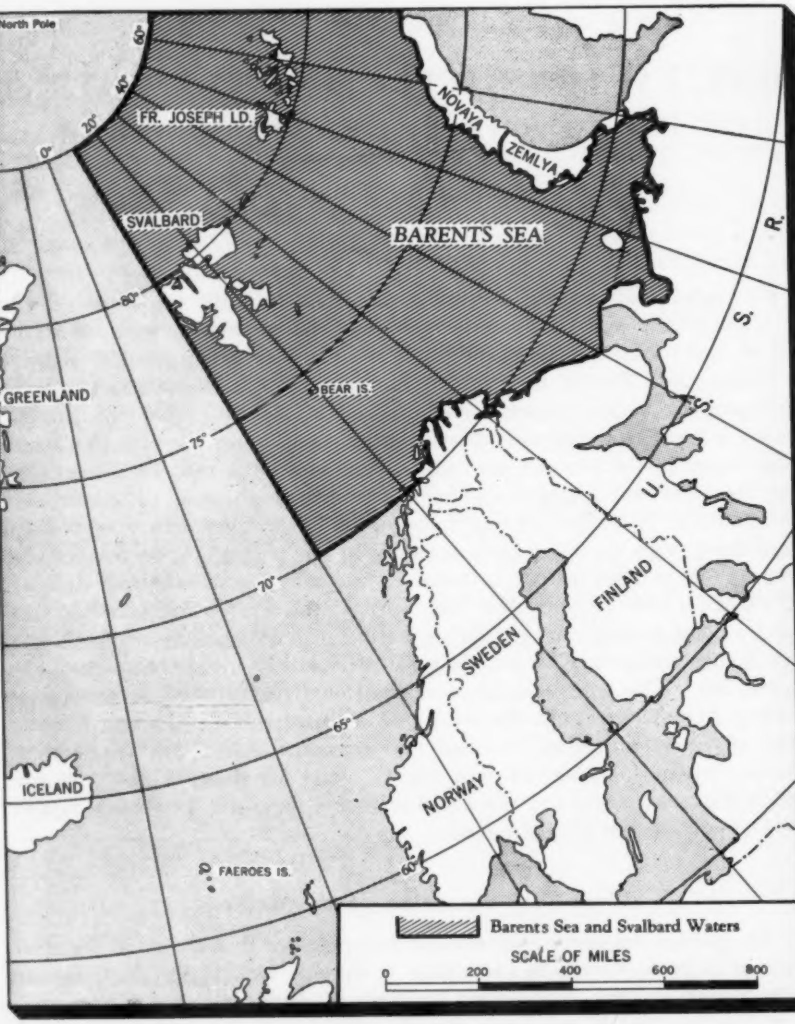

Fig. 1. Barents Sea area.

Charleston may be interpreted as decreased transport of the Florida current and decreasing mean sea level as increased transport. A better picture might have resulted if a tide gauge record had been obtained near the right edge of the current in conjunction with the one near the left edge. However, no such record exists since the gauge at Cat Cay was in operation for too short a period of time.

The mechanism that links the changes in mean sea level at Miami Beach and Charleston with the flow of water of the Gulf Stream system into the Barents Sea is quite simple. Decreased sea level means increased transport in the system, contraction of the North Atlantic eddy, and decreased discharge of warm water across the Wyville-Thomson Ridge. Increased sea level will produce the opposite effects (Iselin, 1938; 1940). To substantiate the case further, Sverdrup (1938) states that increasing sea level is always accompanied by increasing temperatures, and conversely, decreasing sea level by decreasing temperatures; therefore, this approach not only accounts for the variation in water transport, but also in temperature. Our detailed knowledge of the Gulf Stream system is limited, and recent surveys have demonstrated that it is far from being a simple river in the ocean. For the purpose of this study this is unimportant, the current meanders or even turns back on itself occasionally, it widens and narrows, and it also shifts its course. The only important fact is that the Florida current is part of the Gulf Stream system and that part of its waters will reach the area under investigation. Mosby (1938) has investigated this aspect of the problem and arrived at the result that "extreme Spitsbergen-Atlantic water, north of Spitsbergen, should contain nearly 20 per cent of original Gulf Stream water from the Florida current."

Besides sensitivity of the mean sea level to the dynamics of the current, other significant influences to be considered are the direction of the prevailing winds, water temperatures, and atmospheric pressure (Montgomery, 1938). A study by this writer has shown that the influence of the prevailing winds on the mean sea level at the tide stations is only of the order of 0.004 foot for the total variation in the annual mean of wind velocity as determined by the U.S. Weather Bureau; this amount is small enough to be neglected. The correction for atmospheric pressure was based on the premises of Dietrich (1937), but as it would have been technically impossible to plot thousandths of an inch, the method was simplified by correcting with a factor of 12 to 1 instead of 13.2 to 1. In other words, for 0.01 inch deviation of atmospheric pressure from the mean, an adjustment of 0.01 foot in sea level was made. In correcting for water temperatures an amount of 0.035 foot was used for each degree Fahrenheit deviation from the mean (Montgomery, 1938). Direction and intensity of the winds over the Barents Sea area have been considered in detail in this study. The Atlantic low pressure trough, also called the arctic front, extends over the Barents Sea area each year during the period of investigation and divides two different air masses. North of the front there is cold, continental polar air with northerly winds, south of the front there is warm, maritime polar air with southerly winds (Haurwitz and Austin, 1944). The longitudinal position of the arctic front changes from year to year, and since northerly winds drive ice from the polar basin into the area, this position seems to be important. The farther south the position of the arctic front, the larger will be the part of the Barents Sea area under the influence of cold air masses with northerly winds, and the larger should be the area covered by ice. Tabulated mean annual pressure data by intersections were plotted and mean annual

pressure charts of the northern hemisphere were constructed. The position of the arctic front was determined and that part of the area covered by continental polar air was measured. The pressure gradient over the same area was determined in order to obtain an indication of the intensity of the wind. To make it possible to combine these two criteria and plot them as a graph, an index number was calculated by multiplying the area, expressed as percentage of the total, by the pressure gradient, and dividing the result by 100. By this process an index figure was obtained that stands in the following relationship to the distribution of ice in the area under investigation: the larger the index figure, which is another way of saying the larger the area covered by cold air and northerly winds and the stronger these winds, the larger is the area covered by ice.

That the water temperature is more critical than air temperature has been demonstrated experimentally by Sandström (1918). A carefully measured block of ice was placed in flowing water at a temperature of 8°C. The experiment was conducted in a room, and although it is not stated, it is safe to assume that the air temperature was about 20°C. During the same length of time, about ten times as much ice was melted from the submerged part of the block as from the exposed part.

The time lag between the observed fluctuations of mean sea level at Miami and Charleston, the correlated changes in energy transport by the Florida current, and the effects of these changes in the Barents Sea area present a very important, but difficult problem. Since no direct evidence is available at present, the discussion must be concerned for the most part with indirect and supporting evidence. Zubov (1933) has made an estimate of this time lag. He concluded, on the basis of a statement by Sandström (1931), who said that the temperature of the Florida current in the summer of 1928 was 5° above normal, that the very favourable ice conditions encountered in the northern Barents Sea by the *Knipovitch* and *Persei* expeditions in the summer of 1931 and the conditions north of Svalbard found by the *Quest* expedition in the same summer were caused by a "hot wave" emanating from the Gulf of Mexico and the Atlantic Ocean in the earlier year. Zubov even thinks that he circumnavigated Franz Josef Land in the summer of 1932 "on the crest of this 'hot wave'".

The preceding estimate of the time lag is based upon one year's temperatures. A thorough search through available sources has revealed, however, that not enough temperature data are available to follow a "hot wave" or "cold wave" through the current system.

A new approach to arrive at a fairly reliable time lag was attempted through the use of current velocities. The best basis for the calculation of mean velocities would have been a great number of velocity cross-sections computed for many years at numerous points along the Gulf Stream system. Such a record is not available. As the next best source monthly current charts of the North Atlantic Ocean (U.S. Navy Hydrographic Office, 1946) were used.

A hypothetical water particle was followed on its fastest route from the entrance of the Straits of Florida (25°N, 80°W) to the vicinity of the Wyville-Thomson Ridge (about 60°N, 17°W). In this computation a month was figured as closely as possible to 30 days, without dividing a 1° square. The procedure is as follows: a water particle passing through 25°N, 80°W on the first of August was followed for about 30 days on the August chart, then, figuratively speaking, transferred to the September chart, and so on, until it reached 60°N, 17°W. The results of this computation, with starting dates of August 1 and February 1, are shown in Table 1.

Table 1. Mean surface velocities in the axis of the Gulf Stream system from the entrance of the straits of Florida to the vicinity of the Wyville-Thomson Ridge

Month	*Co-ordinates*	*Distance in naut. miles*	*Number of days*	*Aver. dist. per day*
August	38N 64W	1250	32.1	38.9
September	40N 54W	460	28.4	15.9
October	42N 47W	325	30.1	10.8
November	44N 39W	370	32.2	11.5
December	45N 35W	170	29.3	5.8
January	47N 30W	220	31.9	6.9
February	48N 26W	170	32.1	5.3
March	50N 23W	130	30.2	4.3
April	53N 20W	190	28.0	6.8
May	56N 18W	130	28.3	4.6
June	58N 18W	120	29.3	4.1
July	60N 18W	120	15.2	7.9
			347.1	
February	38N 66W	1150	30.9	37.2
March	39N 55W	500	31.0	16.1
April	42N 47W	410	32.8	12.5
May	46N 42W	340	33.0	10.3
June	49N 37W	250	26.6	9.4
July	49N 32W	195	28.7	6.8
August	49N 29W	115	30.3	3.8
September	50N 25W	165	31.1	5.3
October	53N 21W	220	30.1	7.0
November	57N 18W	240	28.9	8.3
December	60N 16W	180	23.2	7.6
			326.6	

February and August were chosen as starting months because in these months the oceanic winter and summer reach their peak. The number of days spent in travel average 336, or approximately 11 months. Since the velocity of a current is usually highest near the surface, this figure can be accepted as the *minimum* time lag between the Straits of Florida and the Wyville-Thomson Ridge.

As to the time lag from the Wyville-Thomson Ridge to Svalbard and the Barents Sea, there are indications (Helland-Hansen, 1934; Mosby, 1938) that the velocities of the Norwegian current and the Spitsbergen-Atlantic current are fairly uniform throughout their courses. They seem to diminish appreciably only after the latter current has rounded the northwest corner of West Spitsbergen. The overall distance from the Wyville-Thomson Ridge to this

point is about 1460 nautical miles. The average velocity throughout the entire body of this current has been computed by the writer to be 3.67 nautical miles per day (Helland-Hansen, 1934). Under the assumption of a fairly uniform velocity of the current, this would mean that it takes the energy about 400 days or about 14 months to travel from the Wyville-Thomson Ridge to the northwest corner of West Spitsbergen.

The distance involved via the North Cape current into the Barents Sea is about the same as the one described above, and although no velocity calculations could be made because of the lack of velocity sections, it is safe to suppose that the time lag is similar.

Then, adding to the minimum approximate figure of 14 months the minimum time lag of one year from the straits of Florida to the Wyville-Thomson Ridge, it appears that the variations in the flow of the Florida current will make themselves felt in the third year thereafter in the Barents Sea area.

Method of presentation

In order to show in a simple manner the influence of the Gulf Stream system on ice conditions in the Barents Sea (Fig. 1) the basic data in Table 2 were plotted as graphs (Fig. 2) from three base lines according to a rule derived from Iselin's theory of the expansion and contraction of the North Atlantic eddy (1938; 1940). It would have been more desirable to use a continuous record from the tide gauge at Miami Beach since it is considerably closer to the edge of the Florida current and therefore more sensitive than the

Table 2. Basic data. Annual means of sea level at Charleston, S.C., and Miami, Fla., corrected for atmospheric pressure[1] and surface water temperature[2]. Ice data. Index of northerly winds.

Year	*Annual means of sea level in feet above zero of staff*		*Ice data in per cent of 2,170,000 km.*[2]	*Index of northerly winds*
1922	Charleston[3]	4.99	–	–
1923	"	4.93	–	–
1924	"	5.00	–	–
1925	"	5.03	46	1.4
1926	"	4.82	53	0.7
1927	"	4.87	55	2.0
1928	"	4.96	51	1.2
1929	"	4.94	56	1.4
1930	"	4.95	46	1.0
1931	"	4.82	45	0.8
1932	Miami[4]	3.29	50	1.5
1933	"	3.40	43	1.1
1934	"	3.30	51	0.9
1935	"	3.40	51	1.3
1936	–	–	46	1.0
1937	–	–	43	0.5
1938	–	–	43	1.0

[1] Correction for atmospheric pressure: 0.01 inch = 0.01 foot
[2] Correction for surface temperature: 1°F = 0.035 foot.
[3] Mean atmos. press. 30.06 inches, mean sea surf. temp. 68°F.
[4] Mean atmos. press. 30.04 inches, mean sea surf. temp. 78.8°F.

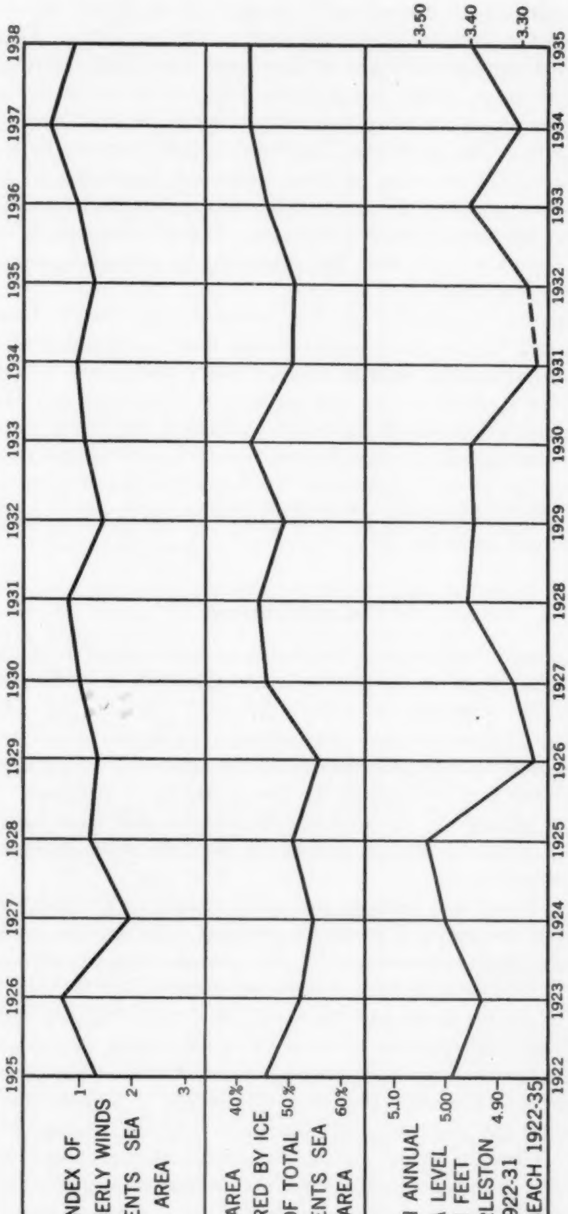

Fig. 2. Graphical representation of the basic data of Table 2.

one at Charleston. Unfortunately, the gauge at Miami Beach was not installed until 1931, and the first full year of record available is 1932. To provide an adequate record, the sea level data at Charleston were used for the years 1922 to 1931, and those at Miami for 1932 to 1935. The sea level curves were plotted in such a way as to bring their overall mean for their periods of record on the same line. The mean for Charleston is 5.09 feet and that for Miami Beach 3.52 feet. The time lag of three years was taken care of by plotting the corresponding years on the same vertical line. Sea level data were plotted from the lower base line increasing upward. The ice data and the wind index were plotted from the upper base line, increasing downward. All curves were plotted to the same scale.

Following these guides the method becomes quite clear. Low sea level at Charleston and Miami Beach means strong flow, contraction of the North Atlantic eddy, little warm Atlantic surface water discharged into the Barents Sea area, and therefore more ice; high sea level at Charleston and Miami Beach means weak flow, expansion of the North Atlantic eddy, more warm Atlantic surface water discharged into the Barents Sea area, and therefore less ice. A similar rule applies to the wind index. A large area covered by continental polar air and strong northerly winds should mean more ice; a small area and weak winds should mean less ice.

The relationship

It is not possible at present to make a quantitative analysis of the relationship between changes in sea level and ice coverage. Neither the data nor our knowledge of the transport of energy in ocean currents are adequate for such a purpose. However, they are sufficient to permit a qualitative interpretation. In other words, this means that it is impossible to say that a change in sea level of 0.05 foot changes the ice cover by, say, 5 per cent. But it can be said that an increase in sea level for the reasons that have been explained should cause a retreat of the ice, and that a decrease in sea level should have the opposite effect.

Examining Fig. 2 and keeping the above statement in mind, one can say that the trend of the curves is generally the same. Taking the sea level curve and the ice curve under closer scrutiny, it is seen that they move up and down together in all cases, except two, that is, the pairs 1924/1927 and 1934/1937. With regard to the ice curve and the wind curve the deviations occur in 1926 and 1934. These discrepancies between the three curves do not occur at the same time. In each case there is good agreement between the plotted phenomena in 12 of the 14 cases. This does not permit a definite answer to the question whether the current or the distribution of the atmospheric pressure has a stronger influence on the extent of the ice. However, it is the writer's opinion that it establishes the fact that the inflow of warm Atlantic water through the Gulf Stream system apparently has a strong influence on the areal extent of ice in the Barents Sea area.

All efforts to explain the discrepancies in the relationship between the discussed curves have been unsuccessful. Available data published by the Association d'Oceanographie Physique (1940), for instance, show that mean sea level in 1934 was low throughout the Atlantic Ocean and there is sufficient proof that 1937 was a light ice year (Danske Meteorologiske Institut, 1937). There must have been a disturbing factor in the relationship that cannot be explained at our present state of knowledge. It is the writer's opinion that the pressure distribution does not furnish the answer, because in 1926, to take an example, the pressure distribution should have resulted in a light ice year, whereas it actually was a fairly heavy one.

References

Association d'Oceanographie Physique. 1940. 'Monthly and annual mean heights of sea level'. *Publication Scientifique No. 5.*

Danske Meteorologiske Institut. 1937. 'Isforholdene i de arktiske have. (The state of the ice in the Arctic seas), 1892-1939'. Copenhagen.

Dietrich, G. 1937. I. "Die Lage der Meeresoberfläche im Druckfeld von Ozean und Atmosphäre"; II. "Ueber Bewegung und Herkunft des Golfstromwassers". *Veröffentlichungen des Instituts für Meereskunde an der Universität Berlin,* Neue Folge, A. Heft 33, pp. 1-91.

Haurwitz, B., and J. M. Austin. 1944. Climatology. New York.

Helland-Hansen, B. 1934. 'The Sognefjord section. Oceanographic observations in the northernmost part of the North Sea and the southern part of the Norwegian Sea'. *James Johnstone Memorial Volume.* Liverpool: pp. 257-75.

Iselin, C. O'D. 1938. 'A promising theory concerning the causes and results of long-period variations in the strength of the Gulf Stream system.' *Trans. Am. Geophys. Union,* 19th Annual Meeting, pp. 243-44.

1940. "Preliminary report on long-period variation in the transport of the Gulf Stream system". *Papers in Physical Oceanography and Meteorology,* Vol. 8, pp. 1-40.

Jacobson, J. R. 1943. 'The Atlantic current through the Faeroes-Shetland channel and its influence on hydrographical conditions in the northern part of the North Sea, the Norwegian Sea, and the Barents Sea'. *Rapp. et Proc.-verb. des Reunions,* Cons. Perm. Int. p. l'Explor. de la mer, Vol. 112, pp. 5-47.

LaFond, E. C. 1939. "Variations of sea level on the Pacific coast of the United States". *J. Mar. Res.,* Vol. 2, pp. 17-29.

Montgomery, R. B. 1938. "Fluctuations in monthly sea level on eastern U.S. coast as related to dynamics of western North Atlantic". *J. Mar. Res.,* Vol. 1, pp. 165-85.

Mosby, H. 1938. "Svalbard waters". *Geofysiske Publikasjoner,* Vol. 12, No. 4.

Sandström, J. W. 1918. 'The hydronamics of Canadian Atlantic waters'. *Canadian Fisheries Expedition 1914-15.* Ottawa.

1931. "Der Golfstrom und das Wetter". *Gerlands Beiträge zur Geophysik,* Vol. 32, pp. 254-59.

Sverdrup, H. U. 1938. "Research within physical oceanography and submarine geology at the Scripps Institution of Oceanography during April, 1937, to April, 1938". *Trans. Am. Geophys. Union,* Vol. 19, pp. 238-42.

U.S. Navy, Hydrographic Office. 1946. 'Current atlas of the North Atlantic Ocean'. *H. O. Misc. 10,688-1 to 12.* Washington.

Zubov, N. N. 1933. "The circumnavigation of Franz Josef Land". *Geogr. Rev.,* Vol. 23, p. 394ff.

1948. 'In the centre of the Arctic', (transl. by E. Hope). Defence Sci. Inf. Service, Ottawa: 1950.

THE GREENLAND BIRD-BANDING SYSTEM

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BIRD-BANDING is carried out only to a limited extent in the Arctic today, although information on birds there is probably more urgently needed than elsewhere for both economic and scientific reasons. Many arctic birds make more extensive migrations and cover longer distances than is usual among boreal birds; these migrations can be studied in detail only by banding.

Before the Greenland bird-banding programme was started, no regular banding system was in operation in any part of the Arctic. The banding of a few sea birds, particularly kittiwakes (*Rissa tridactyla*), common murres (*Uria aalge*), and herring gulls (*Larus argentatus*), had been carried out by the Russians on the coast of Pol'uostrov Kol'skiy (Dement'ev, 1955; Kartashev, 1955). Arctic waders were banded at some Scandinavian stations (Jären in Norway, Oeland in Sweden, and Amager in Denmark) during spring and fall migrations, but no banding was carried out on their arctic breeding grounds. The inaccessibility of breeding localities, the nomadic habits of most of the human population and the lack of competent, educated personnel made it difficult to carry out regular bird-banding programmes in the Arctic. In Greenland these difficulties have been overcome to a large extent. Trade and other economic matters are handled by the government, and Danish officials are stationed at regular intervals along the extensive coasts as managers of settlements and outposts, or as employees at weather stations. The native inhabitants are in frequent contact with the officials, and they can be interested in bird-banding by the offer of a modest reward for their co-operation.

This idea was developed by the late Dr. Alfred Bertelsen, Medical Officer of Umanak District, West Greenland, who, with the help of Greenlanders, banded a total of 681 birds, mainly eiders (*Somateria mollissima*) and kittiwakes, in the years 1926-34. During 1936-39 only 51 birds were banded, mainly great black-backed gulls (*Larus marinus*) and Iceland gulls (*Larus glaucoides*) (Bertelsen, 1948).

After the Second World War bird-banding was organized at my request as a joint enterprise by Grønlands Styrelse (now Ministeriet for Grønland) and the Universitetets Zoologiske Museum, København. The Zoologiske Museum, which furnishes the banding material and acts as the centre of the project, is interested chiefly in the scientific aspects, while the Ministeriet for Grønland being aware of the importance of birds as a source of food in Greenland, is interested in the information for its economic value. It has been agreed that the banding programme is to be organized by the administrative officials throughout Greenland as a part of their duties, as outlined in instructions issued in "Kungørelser fra Grønlands Styrelse", 1946, No. 1. According to

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these the banding is carried out as follows. In early spring parcels of bands and notebooks are sent to all managers of settlements and outposts, a total of about 80 persons. The local manager then chooses a fully reliable man to undertake the banding during the summer. In about half the settlements it has been possible to find suitable men, but if they are not available the banding material is not used. The bands are supplied in eight sizes, No. 1, the largest, is suitable for sea eagles, and No. 8, the smallest, is used for passerines. The bands are shipped in envelopes, each containing 10 to 20 bands of one size. A list of the species of birds for which the bands can be used is printed in Greenlandic and Danish on the outside and the serial numbers of the enclosed bands are marked on it in ink. Notebooks containing detailed instructions in Greenlandic and Danish are supplied (Fig. 1). After each banding operation the following details are to be recorded: serial number of the band used, name of the species banded, date and locality of banding, and remarks, such as the age of the bird (adult or nestling) and mode of capture. In the fall, when the banding season ends, the local manager collects the notebooks and unused bands and sends them to the District Commissioner, who in turn delivers them to the Universitetets Zoologiske Museum.

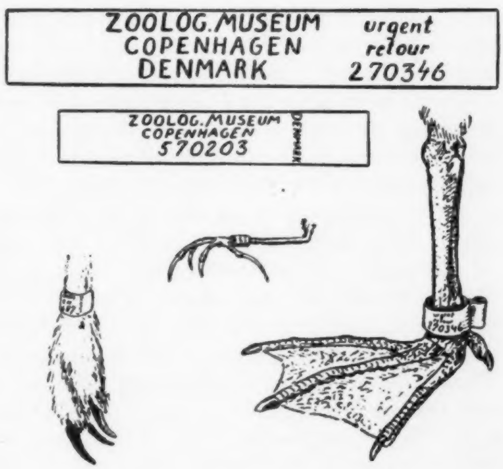

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Fig. 1. Page of notebook with instructions in Danish and Greenlandic, handed to all bird-banders in Greenland.

In order to encourage the work, a reward is paid for each bird banded. The amount varies with the difficulty of banding, but in general the larger the bird, the bigger is the reward. The rate for the sea eagle is set especially high in order to encourage the natives to band the nestlings of this rare species, instead of killing them for food.

Table 1. Rewards paid for the banding of various species of birds.

Name	*Reward in Danish Kroner**	
	up to 1953 incl.	*from 1954 on*
Sea eagle	10	10
Goose	3	7.20
Cormorant, falcon	2	4.80
Raven, duck, loon	1	2.40
Gull, wader, auk	0.50	1.20
Kittiwake, tern	0.25	0.60
Redpoll, Lapland longspur	0.10	0.24
Snowbunting	0.05	0.12

*one Danish Kroner is equivalent to about $0.14.

A reward is also offered for the recovery of banded birds. For each bird shot, caught, or found dead 2 Kroner are paid if the band together with the foot is delivered to the local magistrate. He records the number of the band, date, locality and mode of death, and the name of the recoverer, and then sends the material to the Universitetets Zoologiske Museum. The reason for collecting the foot of the bird, which is not the usual procedure in bird-banding, is to provide a check on the identity of the bird without having to rely entirely on the knowledge of the bander.

The number of bands sent to the different centres varies from year to year. Extra large numbers of certain sizes, such as those suitable for eiders or murres, are sent on special request from a manager, or when it seems that the inhabitants are particularly interested in bird-banding. In southwest Greenland, where the natives earn a good summer income by fishing, the demand for bands is slight, while in the more primitive northern areas of Thule, Upernavik, and Umanak some very fine work is done, and the rewards paid for banding represent a substantial addition to the income of the inhabitants. So far no attempts to earn easy money by making false statements have been discovered; close attention by the managers and careful selection of suitable men have discouraged any attempts at dishonesty.

Occasional visits by scientists to the outposts are necessary to stimulate and sustain interest in bird-banding. During travels in Greenland in 1946, 1949, and 1954 the writer made many such visits, and he arranged for other Danish ornithologists to make similar visits in 1948 and 1951. The expenses of the banding programme, amounting to about 10,000 Kroner annually, are paid by the Ministeriet for Grønland. The administration has also published detailed reports on the banding system (in Danish) (Salomonsen, 1948, 1949, 1950, and 1955).

The Greenland banding programme has been operating for ten years and has yielded very good results. In the nine years 1946 to 1954 inclusive, a total of 30,215 birds has been banded, and 2,474 have been recovered, not including young found dead on the breeding grounds. Practically all recoveries are due to shooting, less than one per cent being due to other causes (mainly birds found dead, many of which have probably succumbed after being shot). The recoveries, averaging 8.2 per cent, can therefore be taken as indicating the amount of persecution by man. Table 2 lists the bandings and recoveries by species. It shows that the greater part of the recoveries has been made in Greenland itself, namely 7.6 per cent, against 0.6 per cent abroad. This is because many sea birds restrict their seasonal movements to Greenland waters and are shot during fall and winter in southern Greenland.

Table 2. Species of birds banded in Greenland.

Name	Number of specimens banded			recovered Greenland		recovered abroad		Total
	1946 –49	*1950 –54*	*Total*	*1946 –49*	*1950 –54*	*1946 –49*	*1950 –54*	
Common loon, *Gavia immer*	1	–	1	–	–	–	–	–
Red-throated loon, *G. stellata*	12	31	43	–	–	–	1	1
Fulmar, *Fulmarus glacialis*	288	688	976	15	39	2	–	56
Cormorant, *Phalacrocorax carbo*	101	250	351	34	73	–	–	107
Canada goose, *Branta canadensis*	1	–	1	1	–	–	–	1
White-fronted goose, *Anser albifrons*	632	149	781	27	28	75	52	182
Mallard, *Anas platyrhynchos*	204	146	350	22	15	–	–	37
Old-squaw, *Clangula hiemalis*	26	7	33	–	1	–	2	3
Harlequin duck, *Histrionicus histrionicus*	2	1	3	1	–	–	–	1
King eider, *Somateria spectabilis*	250	1,718	1,968	13	59	–	2	74
Common eider, *S. mollissima*	271	739	1,010	34	110	–	–	144
Red-breasted merganser, *Mergus serrator*	19	19	38	–	–	–	–	–
Sea eagle, *Haliaeetus albicilla*	19	20	39	7	8	–	–	15
Gyrfalcon, *Falco rusticolus*	11	8	19	1	2	–	–	3
Peregrine falcon, *F. peregrinus*	13	17	30	1	1	–	–	2
Ptarmigan, *Lagopus mutus*	88	70	158	11	14	–	–	25
Ringed plover, *Charadrius hiaticula*	10	6	16	–	–	–	–	–
Ruddy turnstone, *Arenaria interpres*	7	–	7	–	–	–	–	–
Purple sandpiper, *Erolia maritima*	71	60	131	15	12	–	–	27
Red phalarope, *Phalaropus fulicarius*	1	–	1	–	–	–	–	–
Northern phalarope, *Lobipes lobatus*	81	28	109	1	–	–	–	1
Pomarine jaeger, *Stercorarius pomarinus*	13	–	13	–	–	–	–	–
Parasitic jaeger, *S. parasiticus*	39	29	68	3	2	–	–	5
Glaucus gull, *Larus hyperboreus*	335	439	774	42	49	–	–	91
Iceland gull, *L. glaucoides*	691	979	1,670	161	206	–	5	372
Great black-backed gull, *L. maritimus*	103	130	233	23	13	–	–	36
Kittiwake, *Rissa tridactyla*	997	2,737	3,734	55	84	3	1	143
Ivory gull, *Pagophila eburnea*	6	–	6	–	–	–	–	–
Arctic tern, *Sterna paradisaea*	1,897	1,340	3,237	36	19	2	1	58
Brünnich's murre, *Uria lomvia*	807	3,574	4,381	19	139	4	19	181
Black guillemot, *Cepphus grylle*	656	1,275	1,931	114	217	–	–	331
Puffin, *Fratercula arctica*	62	42	104	–	1	–	1	2
Razor-billed auk, *Alca torda*	38	53	91	–	–	–	1	1
Dovekie, *Plautus alle*	803	1,667	2,470	144	293	–	1	438
Raven, *Corvus corax*	69	29	98	10	17	–	–	27
Redpoll, *Acanthis flammea*	62	45	107	1	–	–	–	1
Wheatear, *Oenanthe oenanthe*	720	547	1,267	4	6	2	1	13
Lapland longspur, *Calcarius lapponicus*	725	453	1,178	15	7	–	–	22
Snowbunting, *Plectrophenax nivalis*	1,788	1,000	2,788	30	36	3	5	74
Total	11,919	18,296	30,215	840	1,451	91	92	2,474

The percentages of recovery for a number of the more common species are given in Table 3, where the period of 1946-49 is compared with the whole banding period of 1946-54. The two sets of figures are remarkably uniform. Bearing in mind that the death rate of nestlings among sea birds that nest in colonies is often very high, a loss of more than 30 per cent by shooting, as

Table 3. Percentages and total numbers of recoveries of various birds banded in Greenland.

Name	*Recoveries in Greenland*		*Recoveries abroad*		*Total number*
	1946–49	*1946–54*	*1946–49*	*1946–54*	
Fulmar, *Fulmarus glacialis*	5.2	5.5	0.7	–	56
Cormorant, *Phalacrocorax carbo*	33.7	30.5	–	–	107
White-fronted goose, *Anser albifrons*	4.3	7.0	11.9	16.3	182
Mallard, *Anas platyrhynchos*	10.8	10.6	–	–	37
King eider, *Somateria spectabilis*	5.2	3.7	–	0.1	74
Common eider, *S. mollissima*	12.5	14.3	–	–	144
Sea eagle, *Haliaeetus albicilla*	36.8	38.5	–	–	15
Ptarmigan, *Lagopus mutus*	12.5	15.8	–	–	25
Purple sandpiper, *Erolia maritima*	21.1	20.6	–	–	27
Glaucus gull, *Larus hyperboreus*	12.5	11.8	–	–	91
Iceland gull, *L. glaucoides*	23.3	23.0	–	0.3	372
Great black-backed gull, *L. marinus*	22.3	15.4	–	–	36
Kittiwake, *Rissa tridactyla*	5.5	3.7	0.3	0.1	143
Brünnich's murre, *Uria lomvia*	2.4	3.6	0.5	0.5	181
Black Guillemot, *Cepphus grylle*	17.4	17.1	–	–	331
Dovekie, *Plautus alle*	17.9	17.7	–	–	438
Raven, *Corvus corax*	14.5	27.5	–	–	27

recorded for the cormorant, is certainly too high if the population is to preserve its numbers. The percentage of recovery for the sea eagle, the highest of all, shows that protective measures are urgently needed for this species. A loss by hunting of about 20 per cent, which is usual for the larger gulls (*Larus marinus*, *L. hyperboreus*, and *L. glaucoides*), the purple sandpiper (*Erolia maritima*), guillemot (*Cepphus grylle*), and dovekie (*Plautus alle*), probably does not endanger the population. Recoveries of the dovekie are all due to netting by the Polar Eskimo at the northern breeding grounds, and no recoveries have been made during the wintering period in southwest Greenland. The difference in the percentages of recovery of the common eider and the king eider may be due to the latter being banded only when adult and flightless, while the former is banded in the nestling stage and its recoveries include, therefore, many inexperienced birds that fall an easy prey to the hunter. The small numbers of kittiwakes and Brünnich's murres (*Uria lomvia*) recovered as compared with those for the larger gulls are explained by the fact that the gulls are all littoral species that spend the whole winter close to the coast in south Greenland; the kittiwakes, on the other hand, move south during the fall and spend the off-season in the pelagic zone of the Atlantic, where they are safe from man. Brünnich's murre also spends the winter off shore, where it is not easily accessible.

The recoveries outside of Greenland are of importance for only a few species. It is of interest that no less than 16.3 per cent of the white-fronted geese banded in west Greenland have been shot while wintering in Great Britain, against 7 per cent recovered in Greenland. Some hunting of murres was carried out in Newfoundland before that country became a province of Canada, but the small numbers killed did not affect the stocks of this bird in Greenland.

The banding has provided valuable information about the migration routes and wintering grounds of the migratory birds of Greenland. All recoveries abroad, amounting to a total of 183 until 1954, have been listed (Salomonsen, 1947–55); it is, therefore, unnecessary to go into details here, nor would it be possible to bring out the significance of individual records in a short article.

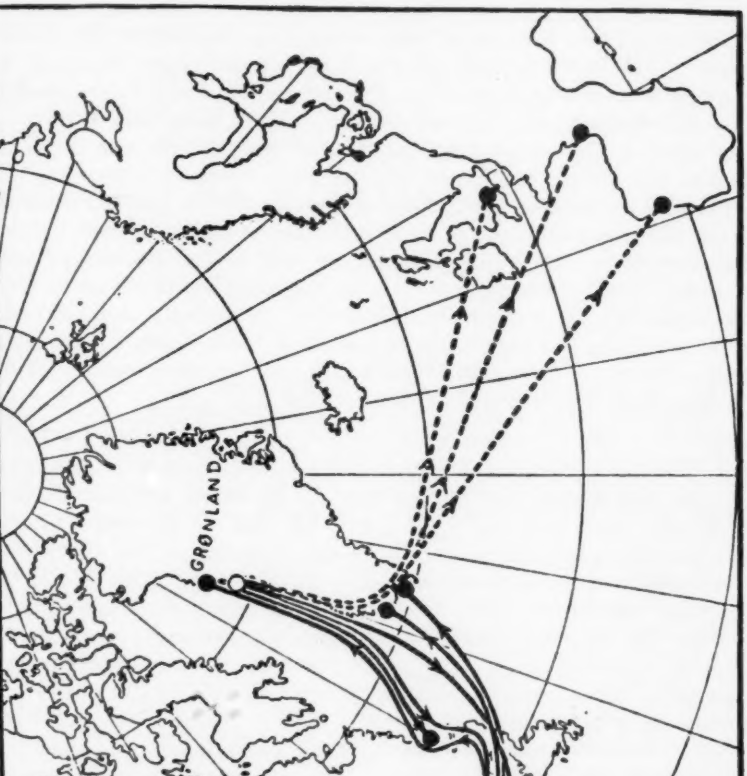

Fig. 2. Migration routes of snowbunting and wheatear, based on recoveries of banded birds. Solid lines: snowbunting; broken lines: wheatear. Open circles: place of banding; solid circles: place of recovery.

However, a few outstanding examples should be mentioned. The recoveries of snowbuntings (*Plectrophenax nivalis*) and wheatears (*Oenanthe oenanthe*) have been mapped in Fig. 2. These two small passerines that share the same breeding grounds in summer, show very different migration patterns in the fall. The snowbuntings move to the interior of Canada, whereas the wheatears

cross the Atlantic and winter in Europe. Old-squaws (*Clangula hiemalis*) that were banded on Disko Island have been recovered as far apart as the Alaska-Yukon border in North America and the Baltic Sea in Europe, displaying an extreme case of so-called abmigration. Two recoveries of king eiders, banded during their moult-migration in late summer in West Greenland, have been made in northern Canada, showing the place of origin of the vast flocks of this species that gather in summer in Greenland waters. A total of 127 recoveries of white-fronted geese that had been banded in West Greenland, shows that the migration route of these birds just touches southwest Iceland and that the majority winter in Eire, whereas a small number stay in Scotland. This pattern was rather unexpected. Among the recoveries of the arctic tern (*Sterna paradisaea*) one is especially noteworthy. A specimen that had been banded in the Disko Bay region was recovered in Natal, South Africa, after travelling a distance of more than 18,000 km. in less than three months. This is the longest flight ever recorded by means of banding.

NOTE:

Since the above paper was completed a new list of recoveries abroad of birds banded in Greenland has been published by the author in *Dansk Ornith. Foren. Tidsskr.* 1957, Vol. 51, p. 33. This list adds 49 recoveries to the previous total of 183 and contains the first results of banding in East Greenland that was started in 1955. Among these are recoveries in the Old World of barnacle goose (*Branta leucopsis*), pink-footed goose (*Anser brachyrhynchus*), and snowbunting (*Plectrophenax nivalis*). Especially noteworthy records of birds banded in West Greenland are: the first recoveries in Canada of Greenland duck hawk (*Falco peregrinus anatum*) and of Lapland longspur (*Calcarius lapponicus*), the third recovery in northern Canada (Boothia Peninsula) of king eider (*Somateria spectabilis*), two further recoveries of snowbunting (one in Ontario and one in Minnesota), and two recoveries of wheatear (*Oenanthe oenanthe*) in Belgium and France respectively.

References

Bertelsen, A. 1948. 'Fuglemaerkningen i Vest-Grønland i aarene 1926–1945.' *Medd. om Grønl.* Vol. 142, No. 4, 33 pp.

Dement'ev, G. P. 1955. "Migratsii moyevki (*Rissa tridatyla* L.)." *Trudy byuro kol'tsevaniya.* Vol. 8, pp. 22–32.

Kartashev, N. N. 1955. "Resul'taty kol'tsevaniya chistikovykh ptits (Alcidae) v SSSR." *Trudy byuro kol'tsevaniya.* Vol. 8, pp. 33–45.

Salomonsen, F. 1947–55. "Preliminary list[s] of recoveries of birds ringed in Greenland." *Dansk Ornithologisk Forenings Tidsskrift.* 1947, Vol. 41, pp. 141–3; 1948, Vol. 42, pp. 100–2; 1949, Vol. 43, pp. 251–5; 1950, Vol. 44, pp. 168–70; 1952, Vol. 46, pp. 110–17; 1955, Vol. 49, pp. 130–5; 1957, Vol. 51, p. 33–9.

1948. "Ringmaerkning af fugle i Vestgrønland 1946 og 1947." *Beretninger vedrørende Grønlands Styrelse.* No. 1, pp. 58–62.

1949. "Ringmaerkning af fugle i Grønland 1948." *Beretninger vedrørende Grønlands Styrelse.* No. 2, pp. 59–61.

1950. "Ringmaerkning af fugle i Grønland 1949." *Beretninger vedrørende Grønlands Styrelse.* No. 1, pp. 81–5.

1955. "Ringmaerkning af fugle i Grønland 1950–54. . . . . ." *Beretninger vedrørende Grønland.* No. 1, pp. 52–4.

REVIEW

THE CLIMATE OF BRITISH COLUMBIA AND THE YUKON TERRITORY

By W. G. Kendrew and D. Kerr. *Ottawa: Queen's Printer, 1955. 9¾ x 6½ inches; x + 222 pages; plates, maps, tables. $1.00.*

Some years ago a series of initial climatological reports was produced, covering the main regions of Canada. These reports were written by university professors across the country, and they were detailed studies of regional climates. There has long been a need for comprehensive studies of the Canadian climate, and the very detailed reports are now being condensed and made available to the public.

The original report on the Mackenzie Basin and Keewatin was extended to cover the southern sections of the Prairie Provinces and published recently as *The Climate of Central Canada.* The reports on British Columbia and the Yukon were combined and have now been published in the same format. Publication of similar handbooks on the climate of Eastern Canada and the Arctic Archipelago will complete a very valuable presentation of the Canadian climate. An interim study of the Far North was published in 1951 (R. W. Rae: *Climate of the Canadian Arctic Archipelago*).

The book on British Columbia and the Yukon makes interesting reading, because it has a very marked touch of the geographer. Before the actual climatic elements are described the reader is taken on a rapid and quite satisfactory excursion across the land. The guide is a man who knows this country well, and the climatic factors of topography, relief, land, and water are clearly understood to be of prime importance in the subsequent explanation and description of regional climates. Also, the two chapters on pressure systems, air masses, and frontal zones very rightly follow the introductory chapters in both parts of the book (southern B.C.; northern B.C. and Yukon). From a groundwork of climatic factors and circulation features the authors go on to describe conditions of winds, temperatures and humidities, clouds, sunshine, precipitation, and visibility. The sections on variability of the climatic elements are especially interesting, and the numerous tables (101 in number) are ably worked into the text. The book is easily read as a whole, and due to good editing it is also possible to find quickly the values of any particular climatic element for most parts of the two large regions included in the study. Apart from being a textbook it is useful as a reference book, and there are two appendices containing climatological tables for 31 stations in southern B.C. and 13 stations in northern B.C. and the Yukon. Some clear photographs and more than 50 figures enhance the value of this useful and reasonably priced publication.

Svenn Orvig

INSTITUTE NEWS

Annual Meeting of the Board of Governors

The Annual Meeting of the Board of Governors was held at the Institute Headquarters in Montreal on November 17, 1956. The following were elected for 1957:

Officers of the Board: Chairman, Dr. Hugh M. Raup, Harvard Forest, Petersham, Mass.; Vice-Chairman, Dr. I. McTaggart Cowan, University of British Columbia, Vancouver, B.C.; Secretary, Dr. M. J. Dunbar, McGill University, Montreal, P.Q.; Treasurer, Dr. Walter A. Wood, Arctic Institute, New York, N.Y.

Governors elected by the Fellows of the Institute: Dr. M. J. Dunbar, McGill University, Montreal, P.Q.; Comdr. D. C. Nutt, The Dartmouth Museum, Hanover, N.H.; Prof. J. T. Wilson, O.B.E., University of Toronto, Toronto, Ont.

Governors appointed by the Board: Philip A. Chester, Hudson's Bay Co., Winnipeg, Man.; Jack C. Haldeman, U.S. Public Health Service, Washington, D.C.; T. H. Manning, 37 Linden Terrace, Ottawa, Ont.; Paul Queneau, International Nickel Co., Inc., New York, N.Y.; Prof. Mogens Westergaard, Genetic Institute of the University, Copenhagen, Denmark; J. R. White, Imperial Oil Ltd., Toronto, Ont.

Retiring Governors: Dr. H. Bostock, Mr. J. C. Case, Dr. H. B. Collins, Jr., Dr. A. E. Porsild, Mr. G. W. Rowley, Prof. M. Westergaard, Gen. H. A. Young.

The Institute Library

During 1956 the Institute Library lent out 489 books, 131 reprints and pamphlets, and 285 journals; in addition 77 inter-library loans were made and 26 received. The holdings of the library increased by 216 volumes, 459 reprints and pamphlets, and 636 maps; 518 volumes were accessioned, making a total of 1,651 accessioned.

The "new" catalogue now has a total of 12,650 cards, both subject and author; this means that 6,480 cards were added in 1956. The "old" catalogue contains an estimated 2,500 cards, and as the process of re-cataloguing continues, cards are removed from the "old" and added to the "new" catalogue. A total of 638 cards was sent to the National Library, Ottawa for inclusion in the Union Catalogue. Thus, 1,856 items in the Institute Library are now listed there.

The library currently receives 202 periodicals and serials. Of these 133 are received in exchange, 24 by subscription, and 45 are complimentary. One hundred and thirty-five books were either bound or re-bound in 1956.

Mrs. B. S. Battle undertook to reorganize the Institute's collection of photographs during the second half of 1956 and completed the cataloguing and classifying of most of the collection.

Gifts to the Library

The Institute Library acknowledges with thanks gifts of books, reprints, and maps from the following persons and organizations:

F. A. Cook
D. V. Ellis
J. K. Fraser
H. B. Hachey
A. D. Howard
J. D. Ives
N. G. B. Jones
A. R. Kelley
E. Palosuo
J. A. Pihlainen
H. F. Quick
P. Suomalainen
J. A. Troels-Smith

P. J. Williams
Argentina, Ministerio de Marina, Instituto Antartico
Canada. Department of Transport, Meteorological Division
McGill University, Physical Sciences Library
Norsk Polarinstitutt
Union of South Africa. Director of Fisheries.
U.S. Army. Office of the Chief of Engineers
U.S. Navy. Office of the Chief of Naval Operations

Activities in Montreal

On September 28, 1956 several scientists who took part in the research work in northern Labrador, northern Quebec, Baffin Island and the Central Arctic during the summer of 1956 and were in Montreal at the time gave brief general outlines of their activities at a well attended press conference at the office of the Institute in the "Bishop Mountain House". Representatives from the local English and French newspapers, radio stations, the Canadian Press, and the Canadian Broadcasting Corporation attended. Speakers were Dr. J. D. Ives, Dr. W. F. Black, J. P. Johnson, D. R. Oliver, and G. Power. All these answered numerous questions during the conference and Drs. M. J. Dunbar and Svenn Orvig discussed the objectives and activities of the Institute.

So far during the 1956-7 winter season three meetings of the Montreal members of the Institute have been held. The first took place in the Faculty Club on October 26, and short talks were given by Dr. Ives, Dr. Black, J. P. Johnson, D. R. Oliver, and J. Power, who discussed their summer's work. In November Dr. D. C. Rose of the National Research Council, Ottawa, addressed the members on the program of the International Geophysical Year.

A joint meeting with the members of the Montreal section of the Alpine Club of Canada was held in December when Jürg Marmet gave an illustrated talk on "The Swiss Lhotse and Everest Expedition 1956". Mr. Marmet showed some outstanding photographs of the conquest of Everest by the Swiss expedition.

American scientists in the Antarctic

In response to an invitation extended by the Navy of the Republic of Argentine to the United States Navy permitting United States scientists to participate in the forthcoming expedition to the Antarctic sponsored by the Argentine Navy, the Arctic Institute of North America has arranged for the following scientists to take part in the expedition: Dr. Warren S. Wooster, Scripps Institution of Oceanography, for oceanographic investigations and Mr. William R. Riedel, Scripps Institution of Oceanography, for biological and geological investigations.

Richard R. McBee, Montana State College, is aboard the ship USS *Curtis* in the American sector of the Antarctic to conduct a biological reconnaissance of antarctic regions. Arrangements for this project have been made possible by the co-operation between the Biology Branch of the Office of Naval Research, the International Geophysical Year, United States Antarctic Programs, the Society of American Bacteriologists, and the Arctic Institute of North America.

Investigations at the Arctic Research Laboratory, Point Barrow, Alaska in 1957

The Research Committee of the Institute approved the recommendations of the Arctic Research Laboratory Subcommittee for the following subcontracts for investigations to be conducted at the Arctic Research Laboratory, Point Barrow, Alaska in 1957 under contractual arrangements with the Office of Naval Research:

Boyd, William L., Arctic Research Laboratory, Point Barrow, Alaska: Ecological and taxonomic survey of microorganisms.

Deyrup, Ingrith J., Barnard College, New York, N.Y.: Continuation of a study of water and electrolyte exchange *in vitro* of tissues of small mammals.

Hanna, G. Dallas, California Academy of Sciences, San Francisco, Calif.: Study of inshore bottom materials; paleontology of the Gubik formation.

Hurd, Paul D., Jr., Dept. of Entomology and Parasitology, University of California, Berkeley, Calif.: Classification and analysis of soil invertebrates collections from Point Barrow, Alaska.

Hussey, Keith M., Dept. of Geology, Iowa State College, Ames, Iowa: Geologic-geomorphic relationships near Point Barrow.

Pitelka, Frank A., Museum of Vertebrate Zoology, University of California, Berkeley, Calif.: Comparative ecology of lemmings and other microtines.

Shanks, Royal E., Dept. of Botany, University of Tennessee, Knoxville, Tenn.: Investigations of the tundra vegetation.

Tedrow, J. C. F., Soils Dept., Rutgers University, New Brunswick, N.J.: A pedologic study of the soil-forming processes of the arctic coastal plain of Alaska.

Teleki, Geza, George Washington University, Washington, D.C.: A methodological study of aerial photography in relation to sea-ice forecast in the Beaufort Sea area.

Thornthwaite, C. W., Laboratory of Climatology, Elmer, N.J.: Study of arctic climatology.

Sable, Edward G., U.S. Geological Survey, Washington, D.C.: Geologic mapping and studies of igneous and sedimentary bedrock in the Mt. Michelson area.

Irving, Lawrence, Arctic Health Research Center, Anchorage, Alaska: Biological reconnaissance at the arctic border between Canada and Alaska.

Campbell, John M., Dept. of Anthropology, Yale University, New Haven, Conn.: Archaeological investigations of pre-Eskimo habitation sites at Anaktuvuk Pass.

Maher, William J., Museum of Vertebrate Zoology, University of California, Berkeley, Calif.: Study of population ecology of the pomarine jaeger.

Miller, Robert C., California Academy of Sciences, San Francisco, Calif.: Study of the effect of radar beams on flying birds.

Revelle, Roger, Scripps Institution of Oceanography, University of California, La Jolla, Calif.: Continuation of tide-gauge and sea-valley studies.

NORTHERN NEWS

The forgotten cairn

There is still a chance, although a slender one, of discovering a despatch from Sir John Franklin, leader of the lost arctic expedition of 1845-48. For oddly enough, although various searchers scoured Montreal Island in the estuary of Back River, none of them realized that on lordly Cape Britannia, 25 miles to the northeast stood a great cairn, which should always have been one of the "letter boxes" of the region.

Standing 14 feet high and composed of ponderous stones, it was erected by Dease and Simpson in August 1839 on one of the northern heights of the long headland. In it they placed a sealed bottle containing a report of their proceedings, as described on pages 373-4 of Thomas Simpson's "Narrative of discoveries on the north coast of America. . . .", a copy of which is known to have been among the books taken by Sir John Franklin on his expedition.

He had also Captain George Back's "Narrative of the arctic land expedition

to the mouth of the Great Fish River", on page 14 of which Back recorded having been directed to build a "conspicuous landmark" at the mouth of the river, and in it deposit a letter for Captain John Ross (then missing in the Arctic) giving notice of the arrangements being made for his relief; instructions not complied with by Back, as he got news of Ross's safety before descending the river.

But the intention was manifest; a large cairn to act as a place of call for letters. So, knowing how Dease and Simpson had made good the deficiency, Sir John would have reasoned that that was the place where anyone coming down river should look for a letter from him, and have had a report of his proceedings deposited there, as well as in Ross's cairn at the Magnetic Pole.

Unfortunately, Sir John Barrow's book "Voyages of discovery and research within the arctic regions from 1818 to the present day" made Dease and Simpson pass Cape Britannia without stopping, consequently all the searchers for news of Franklin who relied solely on it for information about past events never knew of the existence of the cairn and passed it by: Anderson and Stewart (1855), and Captain M'Clintock (1859) to the westward; Captain Hall (1869) to the northward; and Schwatka and Gilder (1879) to the south and westward.

If properly sealed up (as was Dease and Simpson's letter) written records endure long; so if the cairn is still in existence, not one but two wonderful "finds" may have been awaiting discovery on Cape Britannia for many a decade. There is a recent rumour that Eskimo discovered and destroyed the cairn some years ago, but Rasmussen in 1932 did not hear anything of such a discovery (and he spoke Eskimo fluently), whereas he was told about the bones of the white men on Adelaide Peninsula.

So who knows but that the cairn may still stand? As there may be geologists, naturalists, photographers and others intending to visit the Cape Britannia region in the course of a summer's work, perhaps the curiosity of some of them may be sufficiently aroused to turn their steps toward Cape Britannia *and look in the obvious place* for a letter from Sir John Franklin. Even if disappointed in this, Dease and Simpson's "taking possession" document would be a wonderful consolation price.

NOEL WRIGHT

Waterfowl Research Project

The Waterfowl Research Project of the Arctic Institute of North America is designed to gather and publish information on the various factors affecting the migratory waterfowl on the North American continent. Various policies and programs of provincial, state, dominion, and federal agencies in Canada, the United States, and Mexico are being studied and a comprehensive survey is now being prepared.

One of the most difficult portions of the study is the gathering of reliable data on the present day uses of migratory birds, particularly waterfowl, by the native Indians and Eskimo of the Arctic and sub-Arctic. It is known that in some areas, particularly around Hudson Bay, rather large numbers of geese are taken during spring and fall migration. These are used by the natives for both food and clothing. Elsewhere in the Arctic ducks are apparently used to a minor extent for these purposes and the birds taken are mostly sea ducks, such as scoters, eiders and old-squaws. These are indigenous to the North and are of little interest to hunters in southern Canada and the United States. This is not generally known and publication of such facts as can be determined would be of considerable interest and importance to the millions of Canadian and United States citizens who take waterfowl for sport during open hunting seasons.

Mr. Albert Day, Director of the Waterfowl Research Project, is anxious to obtain as many data as possible on this subject. Those who have made observations in northern native communities and

can supply information on the subject will assist this research project by advising Mr. Day of their findings. Black and white photographs of hunting camps, hunting methods, or related activities will also be helpful and appreciated. Data should be sent to the Washington office of the Arctic Institute of North America.

Botanical exploration along the Fort George River, Sakami Lake, and Eastmain River in 1956

On July 28, 1956 Father A. Dutilly and I left the post at Fort George with two Indian guides to travel up the Fort George River. We took an outboard motor along, knowing that it would be useful during one half of the trip. Ascending the Fort George River, one big rapid necessitated a short portage, otherwise the first 50 miles were easily covered. The next 40 miles of the river are usually avoided by the Indians, who prefer to follow a roundabout route either to the north or to the south of the stream. We chose the southern route that leads first down to Lake Duncan and calls for walking over a series of long portages; trudging through swamps, savannas, and pine forests; crossing six small lakes; and rowing along a barely navigable, narrow river. The first leg of the detour to the south of Fort George River, a distance of about 16 miles in a straight line, required eight days of hard labour. Then, heading east, it took another five days before we finally reached Lake Sakami after crossing a series of lakes that lie in a direction parallel to the Fort George River. The crossing of Lake Sakami, a lake over 40 miles long, as well as that of Lake Boyd immediately to the south of it, is rather easy in fair weather. However, we encountered raging winds and spent five more days before we came in sight of the Opinaca River, the main northern tributary of the Eastmain River. The final leg of our expedition required seven more days. All along the course of the Opinaca River are many heavy rapids that mean long portages, some of which have a length of 1 to 3 miles. Thus it was August 24 by the time we arrived at Eastmain Post.

As we had surmised before we left, this expedition led through a region that is dull and very poor from a botanical point of view. What makes the situation worse is that forest fires have devastated more than one-half of this territory. However, this trip from north to south across the drainage basin east of James Bay enabled us to enlarge our knowledge of the northern range of several plants that we had seen along the Rupert River in 1943 and that we had not found again in the course of further expeditions along the Roggan, Wiachuan and Larch rivers in 1945 and 1950. Among these plants may be mentioned: *Kalmia angustifolia*, *Aralia nudicaulis*, *A. hispida*, *Onoclea sensibilis*, *Scutellaria galericulata*, *S. lateriflora*, *Spiraea latifolia*, *Gentiana linearis*, *Betula pumila* var. *glandulifera*.

The discovery of the following plants was quite unexpected: *Osmunda claytoniana*, *Nuphar microphyllum*, *Monotropa hypopithys*, and *Betula michauxii*.

Once again we were able to verify the wide range of some species, whose distribution was very poorly known until a few years ago, such as: *Oryzopsis pungens*, *O. canadensis*, *Deschampsia flexuosa*, *Lycopodium sabinaefolium*, *Epigaea repens* var. *glabrifolia*, and scores of others.

Among the different forest types encountered we identified the following:

Pinus-Kalmia-Vaccinium: *Pinus banksiana*, *Kalmia angustifolia*, and *Vaccinium angustifolium*, with *Lycopodium sabinaefolium*, *Salix humilis*, and *Epigaea repens* var. *glabrifolia*.

Picea-Ledum-Sphagnum: *Picea mariana*, *Ledum groenlandicum*, and *Sphagnum* spp.

Picea-Cladonia: *Picea mariana*, and *Cladonia* spp. (mostly *C. sylvestris*).

This exploration completes our research on the eastern watershed of James Bay, and we hope to make a contribution to the literature on the flora of this region in the near future.

FATHER ERNEST LEPAGE

Biological work at the George River, northern Quebec

During the summer of 1956 the author, accompanied by Mr. B. Bonlander, spent a very profitable ten weeks collecting information on the population of Atlantic salmon (*Salmo salar*) inhabiting the George River, northern Quebec. Mr. Bonlander, besides assisting with this work, carried out botanical investigations in the region around Helens Falls, the party's headquarters. These investigations consisted of making collections of plants from various habitats and also carrying out detailed studies of the microclimate of the heath at various levels above the river.

About 450 salmon were captured and examined between July 15 and September 10; the total was made up of approximately equal numbers of parr, smolts, and mature fish. The lengths and weights of all specimen were recorded, stomach contents were examined, condition of the gonads was noted, and scale samples were collected for age determinations. The main smolt migration took place in July and early August; since the season of 1956 was exceptionally late the migration would probably be a month earlier in a more normal year. The main run of adult salmon entered the river around August 15, but four weeks earlier would again be a more usual date in most years.

Physiological work in the field included measurements of the oxygen consumption of brook trout (*Salvelinus fontinalis*), salmon parr, and salmon smolts. It is hoped that these data will provide information on the respiratory adaptions, if any, of these fish living in northern waters.

Work on other species of fish included the capture and examination of 60 specimens of brook trout, 50 specimens each of *Prosopium cylindraceum* and *Coregonus culpeaformis*, and of a number of specimens of *Cristivomer* (=*Salvelinus*) *namaycush* and *Catostomus catostomus*. In all 12 species of fish were collected in the region. A detailed account of the results of the investigation, which was supported by a Banting Fund grant received through the Arctic Institute of North America, will be published later.

G. Power

Openings for research in the Antarctic

The National Academy of Sciences, National Research Council of the United States of America announces that opportunities exist in the Antarctic program planned by the U.S. National Committee for the International Geophysical Year 1957-58, for scientists, engineers, and technicians at the bachelors, masters, and doctorate levels of training and experience in physics, geophysics, electronics, or closely allied areas. The IGY is an unprecedented study of the physics of the earth in which more than fifty nations are collaborating. The U.S. antarctic program emphasizes the following fields: Aurora and Airglow, Cosmic Rays, Glaciology, Gravity, Ionospheric Physics, Meteorology, and Seismology. Most of the current openings exist in the fields of meteorology and glaciology, although the other fields still require a limited number of specialists.

Research stations have been established at Little America on Marie Byrd Land (Byrd Station), at the South Geographic Pole (Amundsen-Scott South Pole Station), on the Knox Coast (Wilkes Station), and along the Weddell Sea (Ellsworth Station).

The first group of scientists and technicians are now on station and geophysical observations and studies are at present under way. The program of observations will continue until April 1959. A second group will leave the United States about November 1, 1957. Prior to departure, approximately two months of advanced training will be provided in problems of research, instrumentation, and operation in polar regions.

Interested candidates are invited to address enquiries to the following Antarctic Project Leaders:

Aurora and Airglow

Mr. Norman J. Oliver, A. F. Cambridge Research Center, Laurence G. Hanscom Field, Bedford, Massachusetts.

Glaciology, Gravity, and Seismology
Miss Diana Fisher, Glaciological Headquarters Office, USNC-IGY, Room 716, 1145 19th St., N.W., Washington 6, D.C.
Ionospheric Physics
Mr. Harry G. Sellery, Central Radio Propagation Laboratory, National Bureau of Standards, Boulder, Colorado.
Meteorology
Mr. Ervin A. Volbrecht, U.S. Weather Bureau, 24th and M Streets, N.W., Washington 25, D.C.

ELECTION OF FELLOWS

At the Annual Meeting of the Arctic Institute held in Montreal on November 17, 1956 the following were elected Fellows of the Institute:

Dr. A. W. F. Banfield, Canadian Wildlife Service, Ottawa, Ont.
Mrs. Lydia O. Fohn-Hansen, University of Alaska, College, Alaska.
Dr. Elmer Harp, Jr., Dartmouth College, Hanover, N.H.
Dr. J. Ross Mackay, University of British Columbia, Vancouver, B.C.
Dr. R. S. MacNeish, National Museum of Canada, Ottawa, Ont.

GEOGRAPHICAL NAMES IN THE CANADIAN NORTH

The Canadian Board on Geographical Names has adopted the following names and name changes for official use in the Northwest Territories and Yukon Territory. For convenience of reference the names are listed according to the maps on which they appear. The latitudes and longitudes given are approximate only.

Eskimo Point, 55 SW.
(Adopted September 1, 1955)

Turquetil Lake	61°55′N.	95°50′W.

O'Connor Lake, 75 E/5
(Adopted October 13, 1955)

Mansoz Lake	54°17′N.	111°41′W.
Dempsey Lake	54°25′	111°47′

(Adopted January 19, 1956)

LaPerriere Lake	61°26′	111°48′

Marian River, 85 N.
(Adopted December 1, 1955)

Strutt Lake	63°20′N.	116°14′W.
Labrish Lake	63°40′	116°17′
Ketcheson Lake	63°53′	116°50′
Snively Lake	63°49′	116°18′

Wholdaia Lake, 75 SE.
(Adopted January 19, 1956)

Rauta Lake	61°50′N.	105°33′W.
Sammon Lake	61°55′	105°20′
Stephenson Lake	61°43′	105°50′
Vermette Lake	61°24′	105°38′
Gozdz Lake	61°07′	105°53′
Millar Lake	61°09′	104°10′
Atkinson Lake	60°53′	105°52′
Cochrane Lake	60°53′	104°45′
Ruttledge Lake	60°35′	105°52′
Southby Lake	60°39′	105°20′
Wright Lake	60°42′	104°43′
Innes Island	60°42′	104°18′
Burslem Lake	60°18′	105°45′
Eaton Lake	60°20′	105°20′
Bertran Lake	60°26′	104°54′
Flett Lake	60°25′	104°10′
Thomas Lake	60°07′	105°12′
Turner Lake	60°04′	104°43′
Bouskill Lake	60°13′	104°12′
Crowe Lake	61°20′	104°26′
Broad Lake	61°38′	104°15′
Jarvis Lake	61°40′	104°47′
Sinclair Lake	61°52′	104°38′
Foster Lake	61°53′	104°20′

Kazan River, 65 SW.
(Adopted January 19, 1956)

Edwards Lake	61°46′N.	103°50′W.
Crawford Lake	61°58′	103°16′
Nixon Lake	61°33′	103°39′
Dolby Lake	61°28′	103°47′
Arnot Lake	61°18′	103°16′
Suggit Lake	60°38′	103°15′
Ridgers Lake	61°07′	103°10′
Allen Lake	60°56′	103°48′
Meyrick Lake	60°25′	103°45′
Dehoux Bay	60°27′	103°06′
Deering Island	60°13′	103°11′

Jarvis River, 115 B/16
(Adopted January 19, 1956)

Boutellier Creek	60°59′N.	138°14′W.
Jessie Creek	60°57′	138°30′
Sugden Creek	60°54′	138°10′
Bryson Creek	60°53′	138°08′
Hungry Lake	60°59′	138°12′
Telluride Creek	60°52′	138°05′
Sulphur Creek	60°53′	138°02′

Wheaton River, 105 D/3 (E. 1/2)
(Adopted January 19, 1956)

Lemieux Creek	60°01′N.	135°11′W.	
Latreille Creek	60°04′	135°02′	
Stevens Creek	60°15′	135°00′	
Cleft Mountain	60°01′	135°11′	
Millhaven Creek	60°07′	135°00′	
Mount Brown	60°01′	135°02′	not Brown Mountain

Dezadeash, 115A

(Adopted January 19, 1956)

Ferguson Creek	60°40′N.	137°55′W.	not Sugden Creek

Alligator Lake, 105 D/6 (E. 1/2)

(Adopted January 19, 1956)

Idaho Hill	60°19′N.	135°03′W.
Hodnett Lakes	60°18′	135°11′
Dawson Charlie Creek	60°15′	135°07′
Morrison Creek	60°21′	135°09′
Mineral Hill	60°20′	135°14′
Mule Hill	60°21′	135°13′
Goat Mountain	60°25′	135°03′
Lakeview Mountain	60°27′	135°05′
Ptarmigan Hill	60°28′	135°14′
Beresford Hill	60°27′	135°11′

Carcross, 105 D/2

(Adopted January 31, 1956)

Knob Creek	60°04′N.	134°51′W.	
Knob Hill	60°05′	134°48′	
McDonald Creek	60°08′	134°47′	
Brute Mountain	60°06′	134°44′	
Sugarloaf Hill	60°06′	134°39′	
Montana Creek	60°04′	134°34′	
Copper Gulch	60°03′	134°33′	
Ramshorn Creek	60°03′	134°33′	
Escarpment Mountain	60°03′	134°30′	
Watson Ridge	60°14′	134°47′	
Pooly Canyon	60°02′	134°37′	
Spirit Lake	60°15′	134°44′	
Bennett Mountains	60°02′	134°57′	
Millhaven Creek	60°07′	134°56′	
Grayling Bay	60°10′	134°41′	
Bove Island	60°08′	134°31′	
Old Lady Lake	60°00′	134°34′	
Mount Dean	60°01′	134°46′	
Mount Gray	60°09′	134°51′	not Gray Mountain
Dall Peak	60°01′	134°40′	not Red Deer Mountain
Big Thing Creek	60°04′	134°34′	not Montana Creek
Pooly Creek	60°02′	134°37′	not Middle Branch Pooly (creek) nor Uranus Creek
North Canyon	60°02′	134°37′	not North Branch Cañon

Camsell River, 86 SW. and 86 SE.

(Adopted March 1, 1956)

Gordon Point	65°20′N.	119°49′W.
Fenwick Lake	65°21′	119°07′
Yanik Lake	65°22′	118°37′
Leith Lake	65°41′	119°12′
Neiland Bay	65°42′	119°40′
Jebb Lake	65°45′	119°24′
Garland Lake	65°46′	118°57′

M'Clure Strait, 98 NE., 88 NW. and 88 NE.

(Adopted March 1, 1956)

Ballast Brook	74°32′N.	122°48′W.

Amundsen Gulf, 97 NW. and 97 NE.
(Adopted March 1, 1956)

Cardwell Brook	71°27'N.	120°55'W.	
(Adopted April 5, 1956)			
Duck Hawk Bluff	71°52'N.	125°50'W.	not Peregrine Bluff

Robinson, 105 D/7
(Adopted March 1, 1956)

Stevens Creek	60°15'N.	134°58'W.	
Surprise Mountain	60°15'	134°53'	
White Hill	60°19'	134°53'	
Minto Hill	60°24'	134°44'	
Bear Creek	60°26'	134°52'	
Mosquito Hill	60°27'	134°58'	
Blue Lake	60°16'	134°45'	
Mount Gilliam	60°18'	134°52'	not Gilliam Mountain
McConnell Lake	60°27'	134°55'	not Long Lake

Chart 5516, Kocjesse Inlet
(Adopted April 5, 1956)

Best Point	63°44'N.	68°34'W.

Albert Creek, 115 H/12 (E. 1/2)
(Adopted April 5, 1956)

Poplar Lake	61°38'N.	137°32'W.
Thatchell Creek	61°33'	137°35'

Jubilee Mountain, 105 D/1
(Adopted May 3, 1956)

Ten Mile (locality)	60°10'N.	134°23'W.	
Squaw Point	60°03'	134°12'	
Base Mountain	60°09'	134°21'	
Mount Thompson	60°02'	134°19'	
Alfred Butte (hill)	60°04'	134°06'	
Lime Creek	60°05'	134°30'	
Red Range	60°02'	134°03'	
Leine Creek	60°03'	134°09'	
Wolverine Creek	60°00'	134°00'	
Mosquito Creek	60°13'	134°00'	
Moose Brook	60°00'	134°00'	
White Mountain	60°01'	134°29'	not White Range

Takhanne River 115 A/2
(Adopted May 3, 1956)

Squaw Range	60°02'N.	136°58'W.
Devil's Club Creek	60°13'	136°37'
Howard Lake	60°14'	136°48'
Charcoal Creek	60°11'	136°32'
Not adopted		
Frederick Lake	60°13'	136°33'

Dalton Post 115 A/3
(Adopted May 3, 1956)

Name confirmation			
Mount Beaton	60°01'N.	137°02'W.	not Mount Kane

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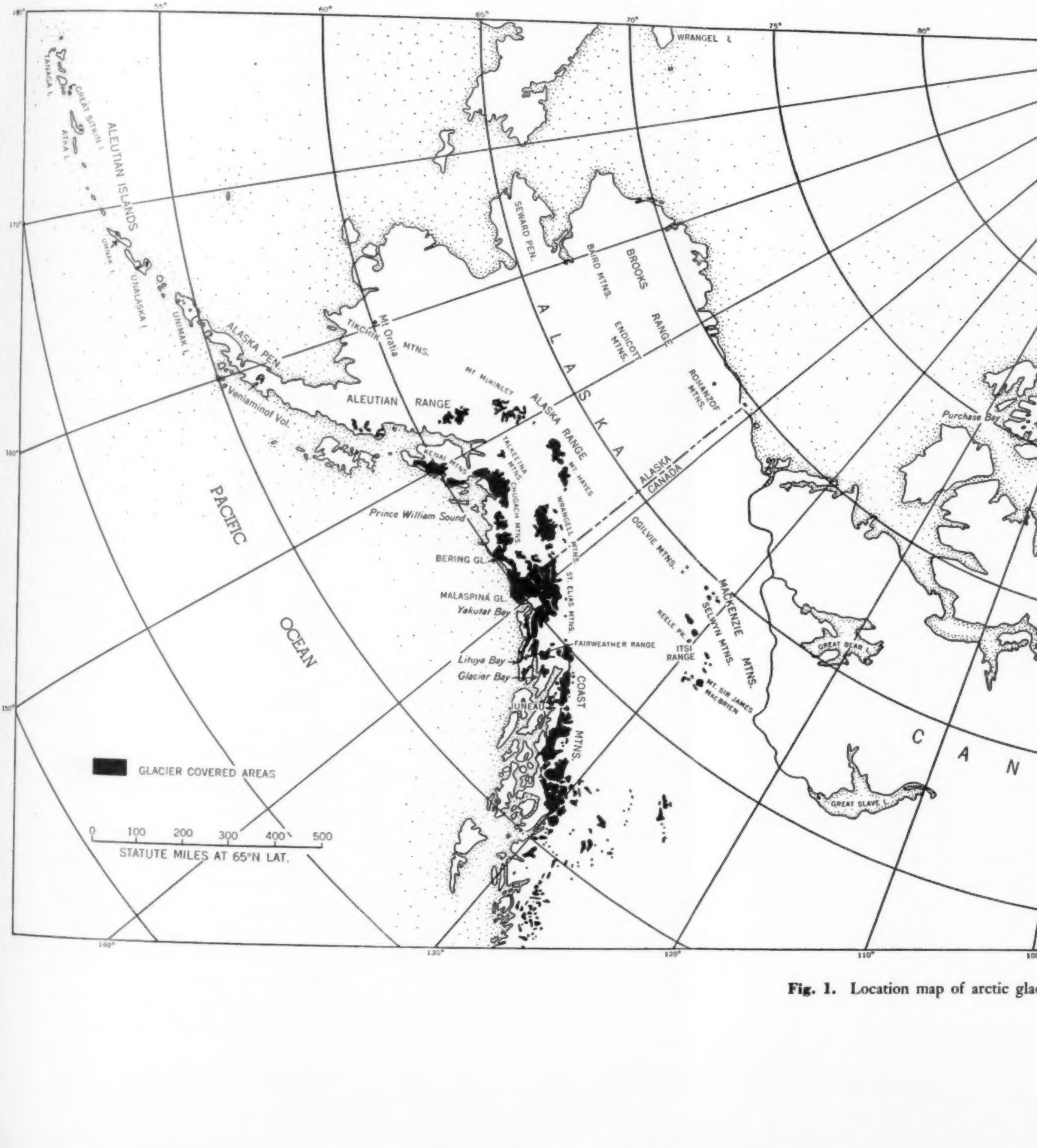
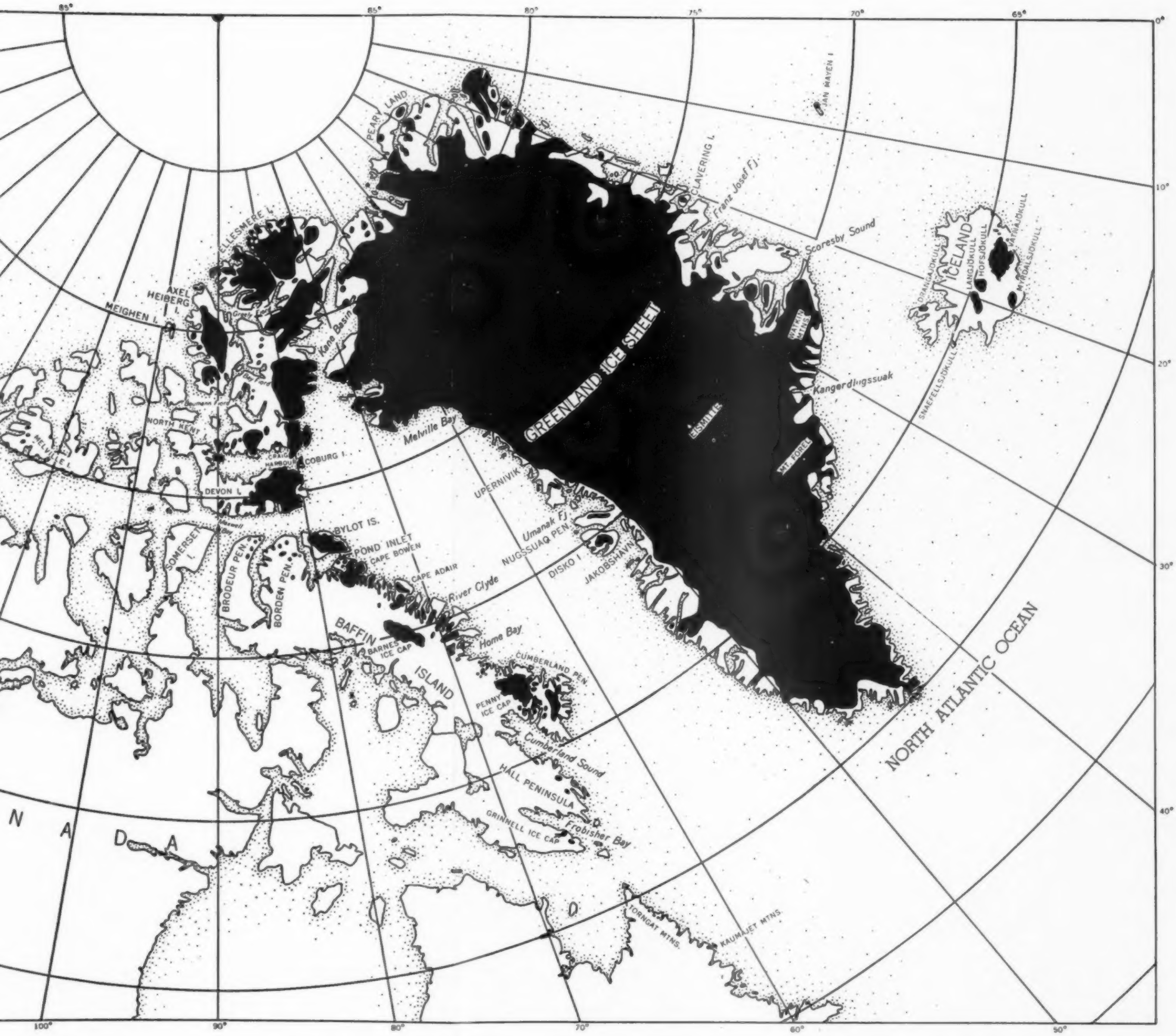


Fig. 1. Location map of arctic gla



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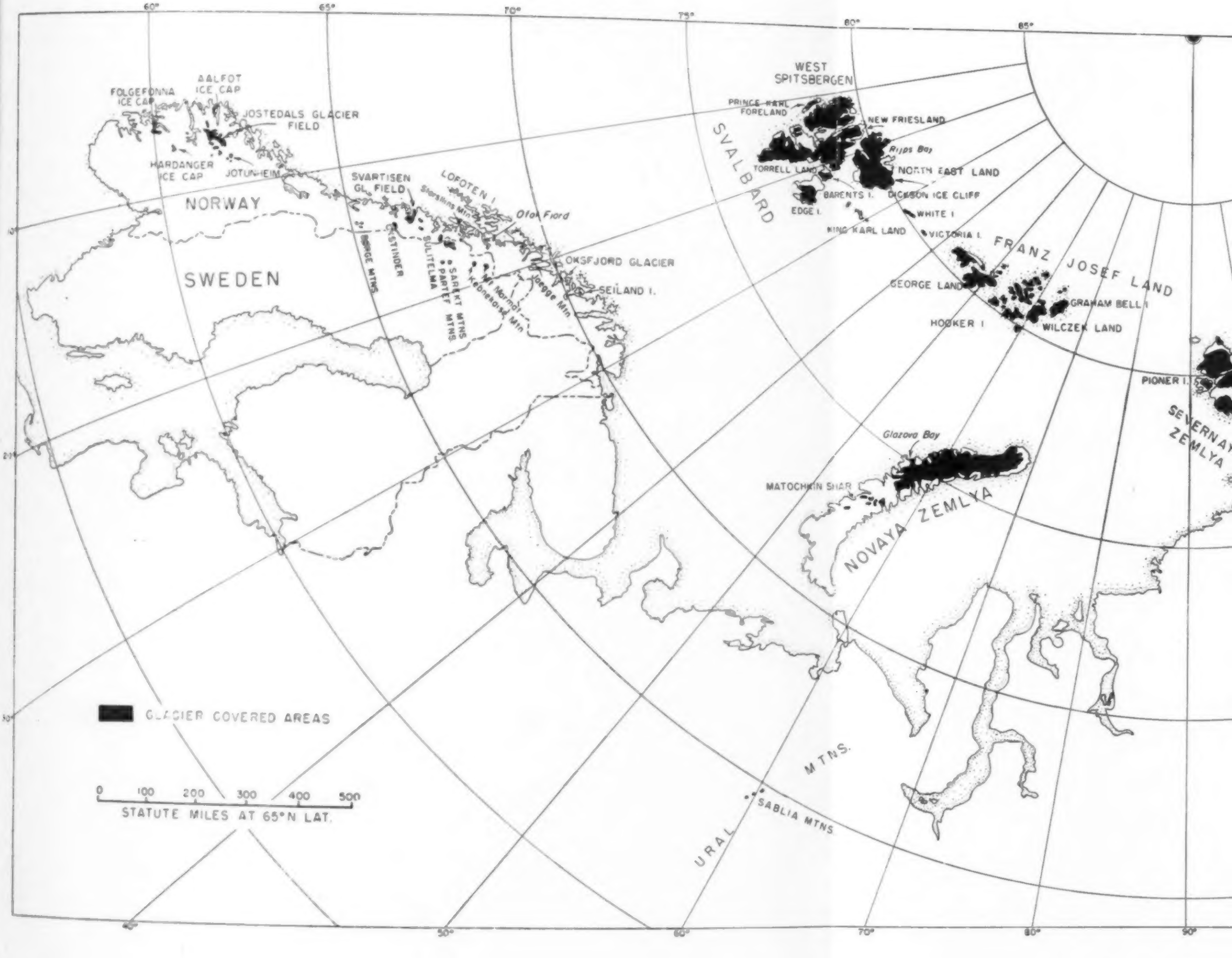
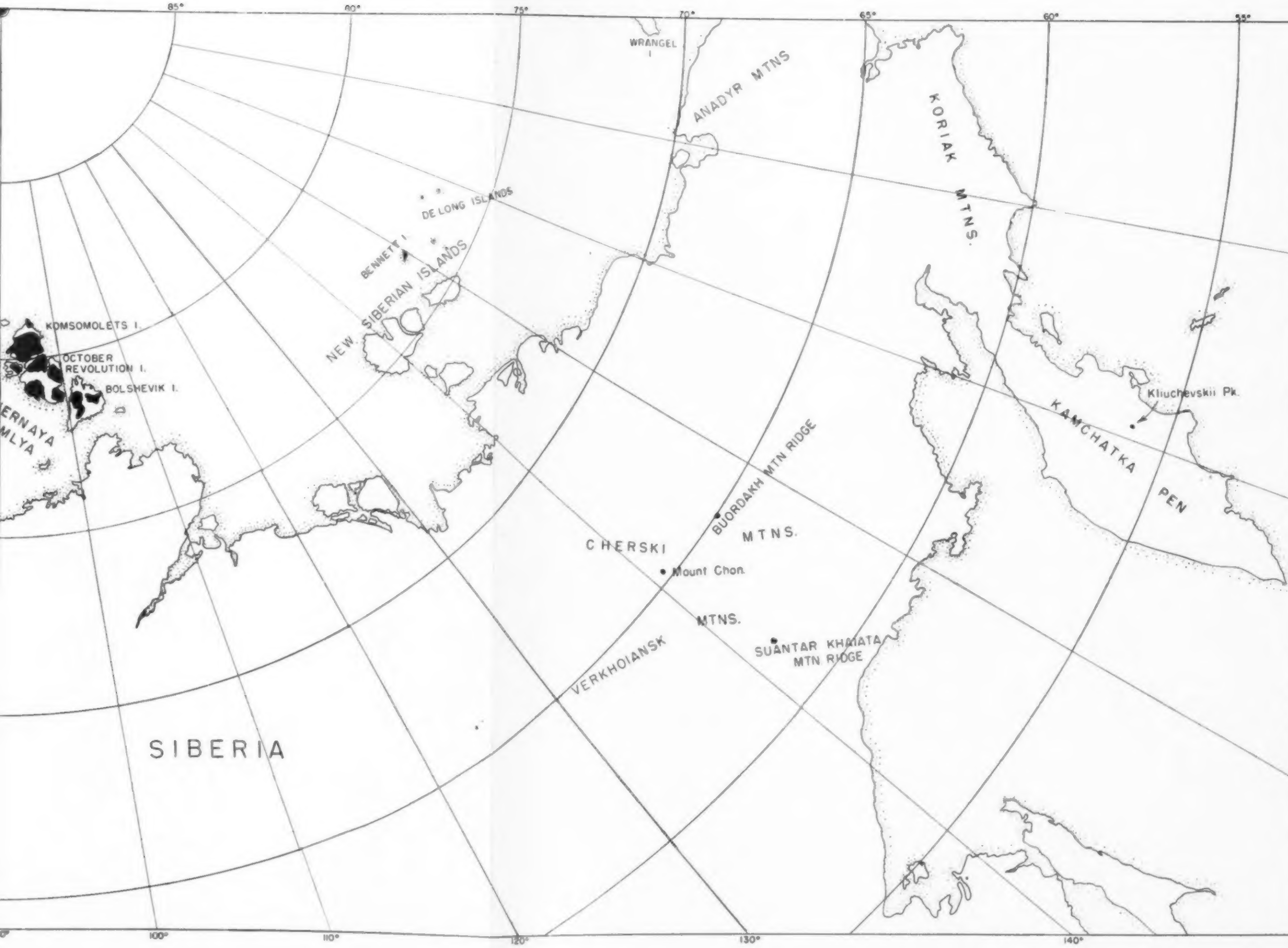


Fig. 2. Location map of arctic g



ctic glaciers in the Eastern Hemisphere.